SCIENTIFIC AMERICAN

No. SUPPLEMENT 788

Scientific American Supplement, Vol. XXXI. No. 788.
Scientific American, established 1845.

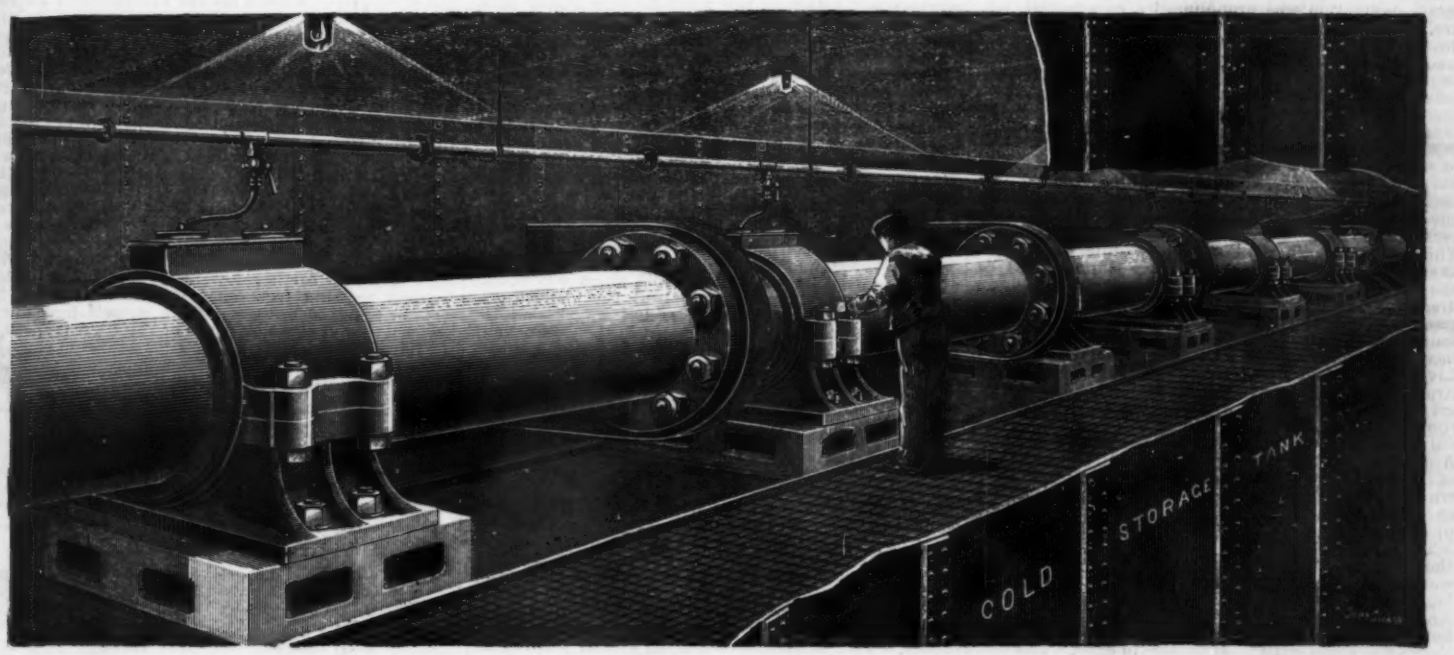
NEW YORK, FEBRUARY 7, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

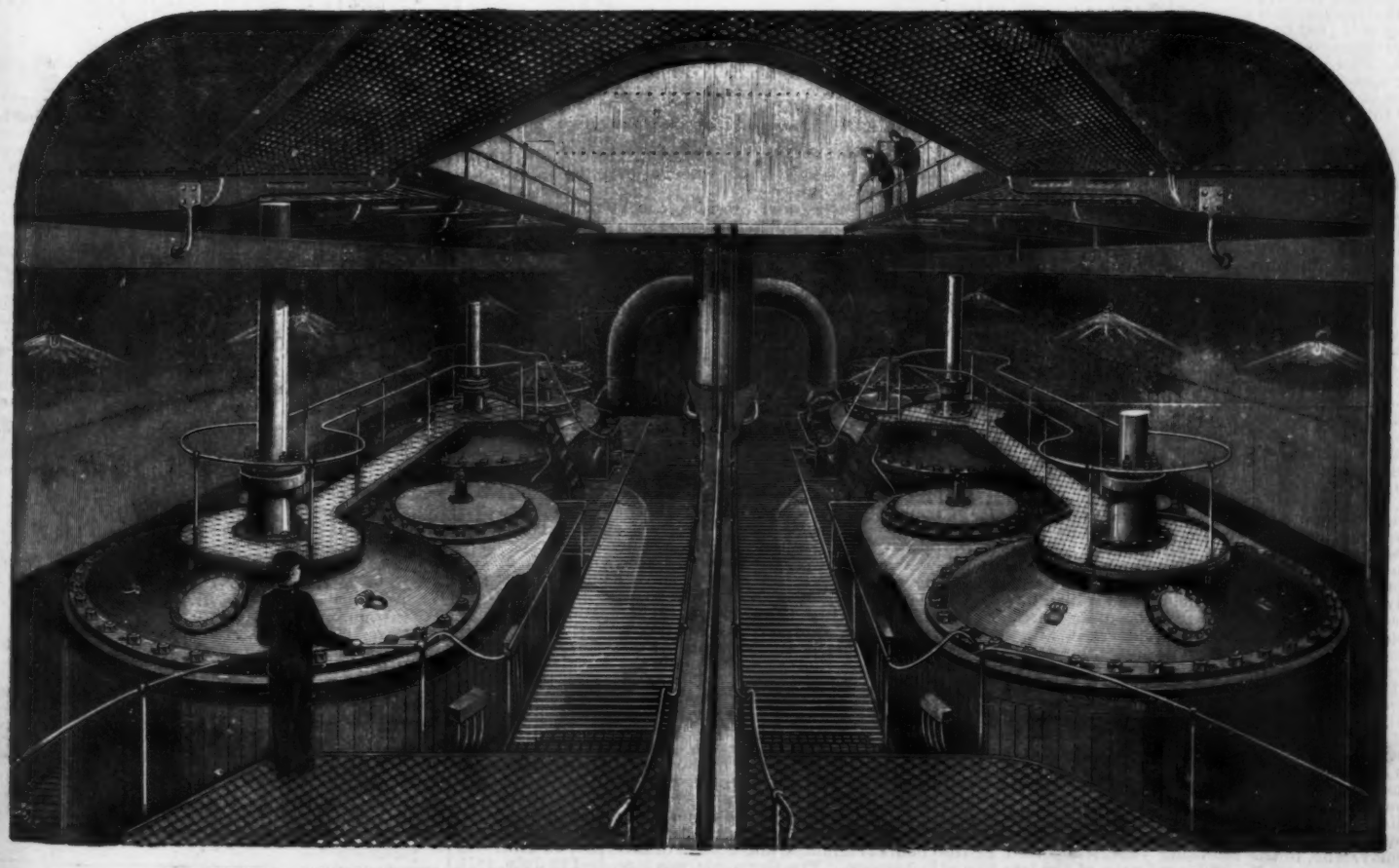
[From The Engineer, London.]

THE WHITE STAR STEAMER TEUTONIC.

In the following pages it will be understood that all that is said concerning the Teutonic applies with equal force to her sister the Majestic. Indeed, the ships differ from each other only in name. The Teutonic and the Majestic are two of the largest ships in the world, if we except one or two Italian ironclads, which possibly have a greater displacement. The displacement of the White Star ships is about 16,000 tons each when they are fully loaded. Those who have not seen either the Teutonic or the Majestic cannot hope to form an adequate idea of what they are really like; and even those who have cannot without trouble realize the enormous amount of talent, skill, artistic feeling, and money that has necessarily been expended in their construction. It is, perhaps, because it seems almost impossible to do so gigantic a subject justice, that the literature, if we may use the word, of Atlantic passenger steamships is deplorably meager. No "popular" description of them worth much consideration has ever been published; and yet the number of individuals possessing little technical knowledge who would like to know a good deal about these magnificent vessels is, we believe, very large. We have for this reason devoted all the space available for illustrations in this issue of *The Engineer* to pictures of the Teutonic and her engines, which are not intended to supply detailed information to highly trained technical readers, but to impart as good an idea as the art of drawing and engraving can compass of the appearance of the ship when steaming in smooth water, and of what may be seen by the voyager fortunate enough to obtain the *entree* of the engine rooms, and to walk through them under the guidance of the chief engineer of the ship, or one of his able assistants. Anything approaching a minute description of the vessel, her machinery, and her fittings, it would be beyond our purpose to give. In the first place, the mere letterpress would fill a bulky volume; and in the second, to go into detail would be foreign to the object we have in view, namely, to impart, as we have said, to the general as well as to the technical reader a fair idea of what is to be seen in the Teutonic and her sister the Majestic. And here,



STEAMSHIP TEUTONIC—STARBOARD TUNNEL.



STEAMSHIP TEUTONIC—GENERAL VIEW OF PORT AND STARBOARD ENGINES FROM TOP PLATFORM.

before going further, it is right that we should express our sense of the courtesy shown to us by Messrs. Ismay, Imrie & Co., and also by Messrs. Harland & Wolff, the former gentlemen giving every possible facility to our special artist, who spent several days on board in the engine room, making his sketches. It is worth while to glance at the history of Atlantic steam navigation, and to say a few words concerning the earlier "crack" steamships carrying mails and passengers across the "herring pond," without going into the dim historical regions when the Royal William and the Savannah came to life.

The first proposal for establishing a regular steam service between this country and New York was made in 1836. Two different schemes were advanced—one advocating the establishment of a line of steamers to ply between the west coast of Ireland and Boston, touching at Halifax, and the other a direct line, making an uninterrupted trip between Bristol and New York. Dr. Lardner maintained that it would not be possible to make such a line pay unless the shortest possible sea route was adopted, and he suggested in 1836-37 that a railway should be made across Ireland, from Dublin to a Western port, such as Galway; and this, with the Liverpool, Birmingham, and London Railway and the Dublin and Liverpool steamships, would form the first portion of a great steam highway between the old and new worlds. The steamers would run from Galway to Boston, touching at Halifax. This scheme was not carried out even in part until very many years afterward, when the enterprise of Mr. Orrell Lever had a disastrous termination. In the years immediately succeeding 1836 seven steamers—the Great Western, the Sirius, the Royal William, the Great Liverpool, the British Queen, the President, and the Great Britain—were started. In the course of fourteen years Atlantic steam navigation was pronounced a commercial failure. The steamers we have named had all been withdrawn or lost. To Mr. Samuel Cunard belongs the credit of permanently establishing a line of steamships between the old and new worlds, and this was only done by the aid of a government subsidy of £145,000 a year. Paddle steamers remained so popular that the Cunard Company had the Persia built in 1856—a magnificent iron paddle steamer of 3,300 tons burthen and 3,600 I.H.P. She had accommodation for 250 cabin passengers, and, as was anticipated, at once became a general favorite. The success attending the Persia induced the company to produce another vessel of the same class, but of increased dimensions. This was the Scotia, the last of the paddle wheels, and as such deserving particular notice. Built in 1862, on the Clyde, by Messrs. R. Napier & Sons, she measured 379 ft. long by 47⅞ ft. broad by 30⅝ ft. deep. Her gross tonnage was 3871. She carried 275 cabin passengers, and before she was long on her station she beat all previous records by running from New York to Liverpool in eight days twenty-two hours. The Persia, Arabia, and Scotia were the last great paddle steamers built for the Atlantic trade. The engines were of the side lever type, the cylinders of the Persia being 100 in. in diameter, with a stroke of 10 ft. Those of the Arabia were 103 in. in diameter and 9 ft. stroke; those of the Scotia, 100 in. in diameter by 12 ft. stroke. The whole of the framing was of wrought iron, with the exception of the head stocks carrying the crank shaft plummer blocks.

The side levers were of cast iron, 6 ft. 6 in. deep in the middle and about 25 ft. long. The paddle wheels were 40 ft. in diameter, and the buckets were 10 ft. long and 3 ft. wide. Steam at 18 lb. pressure in the Arabia and 22 lb. in the Persia was supplied by eight boilers in two groups, one forward and the other aft of the engine room, with five furnaces in each. The daily consumption of coal was 150 tons, and the bunkers held 1,400 tons. The Scotia's engines made about eighteen revolutions per minute, giving what was then regarded as the high piston speed of 432 ft. per minute, or less than half that now common. The engines indicated 4,500 horse power.

It would be foreign to our present purpose to give in any approach to detail an account of the rise and progress of the Atlantic passenger trade. It will suffice to say that the great paddle steamers were superseded by such ships as the Alaska—at one time known as the greyhound of the Atlantic—the Servia, Umbria, and Etruria; while the Inman Company produced such ships as the City of Berlin. The performances of the City of Paris and City of New York are too well known to need more than passing mention here.

The history of the White Star Company may be regarded as typical. It illustrates very clearly what the energy of Englishmen can effect. The day for subsidies has long passed away, and the White Star Company owes nothing of its success to adventitious aid. It is gratifying to recall the fact that the flag which now adorns the fine steamships of the White Star line is the same that was once carried at the trucks of a fleet of sailing clippers years before the idea had sprung into existence that steam would effect marvelous changes in England's mercantile marine.

The origin of the White Star line dates from the epoch of the great rush to the gold diggings of Australia thirty-eight years ago, a period which embraces the change from the old style of small sailing ships to what were at the time considered, and rightly so, the magnificent sailing clippers which carried her Majesty's mails, and from them to the new order of large steamships carrying the White Star flag. We need not dwell on the revolution brought about in the Australian trade by the clipper ships, which in the course of seven years conveyed about half a million adventurers to the gold fields, and which have until recent years almost exclusively been the carriers of a commerce that has steadily increased, although no longer conducted in such a dashing style as characterized the trade during the raging of the gold fever.

In 1864 an important change took place in the fortunes of the flag. The then managing owner of the White Star line retired, and his interest was acquired by Mr. Thomas Henry Ismay, who began by introducing iron ships instead of the wooden clippers that had at first been employed, and which have since been almost entirely superseded. We now come to the great event in the history of the White Star flag—the establishment, in 1869, of the Oceanic Steam Navigation Company, Limited. This was accomplished by Mr. Ismay, who, in the following year, was joined in the management by Mr. William Imrie, of the late firm of Imrie, Tomlinson & Co., in whose office Mr. Ismay and Mr. Imrie had been fellow apprentices. The firm now became Ismay, Imrie & Co. Later, in 1881, Mr. W. S. Graves, son of a former M.P. for Liverpool, became a partner. The Oceanic Company was initiated with so much boldness and judgment that the shares of £1,000 each fully paid were at once privately taken up, chiefly by the joint managers and their friends, including some of the most substantial names in England. Their first step was to order a fleet of new steamships, to be built expressly for the American passenger trade. The order was given to Messrs. Harland & Wolff, of Belfast, and the first ship of the line—the Oceanic—was launched in August, 1870. In the following year the Baltic, the Republic, the Adriatic and the Celtic were added to the fleet, besides the Asiatic and Tropic, Gaelic and Belgic, which were afterward sold. In 1874, two larger ships, the Britannic and Germanic, were built.

Following these, in the order given, came the Arabic and Coptic, Ionic and Doric, Gaelic and Belgic—replacing the two older ships of same names—Cufic and Runic, and in 1889 and 1890 the twin armed cruisers Majestic and Teutonic. By the recent sale of the Baltic, Republic, and Arabic some well known and popular names have been removed from the company's Atlantic fleet, perhaps to be replaced at some future time, as the present Gaelic and Belgic replaced steamers of the same favorite names in the Trans-pacific service of the company. The fleet now consists of fourteen steamships of the aggregate of 73,000 tons, and early in the New Year there will be added two twin screw cargo steamers to be named Nomadic and Tauric, specially constructed and fitted for the Trans-atlantic cattle trade. These, with a handsome passenger tender, the Magnetic—also under construction for the New York and Liverpool mail and passenger service—will bring up the total to over 83,000 tons, rendering the White Star fleet one of the largest and finest in the world.

The Oceanic, the pioneer vessel of the fleet, may be said to have inaugurated an entirely new type of ocean steamer, and she was indisputably the origin of most of the improvements in the internal accommodation in Atlantic passenger steamers which have been so generally adopted. On gliding into the Mersey in February, 1871, her great length, yacht-like lines, and general symmetry created in the minds of those who saw her an admiration which her subsequent success has shown was thoroughly warranted.

Certain it is that since the advent of the Oceanic a marked change has taken place in the equipment of Atlantic liners, and rival steamship owners have one and all exerted every nerve to build ships which, like the White Star liners, should bear the nearest possible resemblance to first class hotels. One of the principal improvements introduced in the Oceanic and her sister ships was the placing of the saloon amidships—a valuable innovation on existing practice, which originated with Mr.—now Sir—Edward Harland.

The Oceanic is still—in her twenty-first year—the favorite passenger steamer on the route between San Francisco, Yokohama, and Hong Kong, and on her sixty-second voyage, in October, 1889, she crossed from Yokohama to San Francisco in 13 days, 14 hours, 4 minutes, at that time the fastest passage on record across the Pacific. The Oceanic has been employed in the Trans-pacific service of the Occidental and Oriental Steamship Company of San Francisco since 1874, in which service the Belgic and Gaelic of the White Star line are also popular ships.

Since 1883 the White Star line has been running three steamers—the Ionic, Doric, and Coptic—in the Shaw, Savill & Albion Company's line, trading between London and New Zealand, each capable of importing 34,000 carcasses of frozen mutton, and making the voyage round the world twice or three times annually.

The earlier steamers of the White Star Atlantic fleet were very remarkable for their uniformity in speed, bringing the passage, which had previously averaged nine and a half to ten days, to about eight and a half days, and each steamer in its turn did the passage under the eight days.

But it was reserved for the Britannic and Germanic to make a decided advance on the Atlantic record. The former, in 1877, crossed from Queenstown to New York in 7 days, 10 hours, 50 minutes, beating the previous best performance of any competing line by three hours, and bringing the Atlantic passage at once into near approach of the seven day limit. Many faster steamers have since been built, and the Britannic's laurels have been taken over by vessels of the Majestic and Teutonic class. But the Britannic still shows her mettle by undiminished and rather increased speed. So recently as September, 1890, she eclipsed her own previous record of 7 days, 9 hours, 30 minutes by 2 hours and 35 minutes, crossing from New York to Queenstown in 7 days, 6 hours, 55 minutes. The following were her daily runs: 292, 372, 377, 370, 376, 377, 397, 261 = 2812 knots. Average speed, 16·08 knots. When it is remembered that this high speed, nearly nineteen statute miles per hour, is obtained in a ship over 16 years old, with her original compound engines and boilers, on a small coal consumption and with a large carrying capacity, it will be seen that the Britannic has been constructed to give results unattainable with the fastest ships of the present day. To show the remarkable uniformity in speed between the sister ships Britannic and Germanic, it may be mentioned that previous to the above passage of the Britannic the record of both ships stood at 7 days, 9 hours, 30 minutes, New York to Queenstown. From 1873 until 1884 the White Star line held its own as the fastest fleet on the Atlantic, and since 1877 has been regularly employed under contract by her Majesty's government in conveying the American mails.

The *Liverpool Mercury* for January 14, 1889, in the course of an article on the White Star steamers, says: "That there have been compound engines constructed of a type which takes a lot of beating from its later rivals is evidenced by the performances of some of the earlier steamships of the White Star fleet, an instance of this being furnished by the Germanic, which left New York on Wednesday morning, the 2d instant, and arrived at Queenstown on Wednesday evening last, the 9th instant, accomplishing the voyage in 7 days 9 hours 27 minutes, and docked in Liverpool on Thursday afternoon. The Germanic was launched in July, 1874, so that she is nearly fifteen years old. She has still her original engines and boilers, and despite her having made 140 round voyages between Liverpool and New York, 280 across the Atlantic, and traveled a distance nearly 1,000,000 English miles, she now makes a passage from Sandy Hook to Queenstown in five hours less time than she has ever done before. Even this, however, was equaled by the Germanic's sister ship, the Britannic, which crossed from Sandy Hook to Queenstown last March in 7 days 9½ hours, her fastest passage after fourteen years' work. It cannot be doubted that to the superior model of the ships, designed as they were by Sir Edward Harland, of Belfast, much of this wonderful efficiency is attributable; and to the care and expense which have been bestowed upon them by the marine and engineering superintendents of the company in keeping them up to a high standard of working order, there is also a great deal owing. It is unusual to find a record of regular and fast steaming for a lengthened period such as that possessed by the Britannic and Germanic. These two vessels, in eighty-three voyages from Queenstown to New York, show an average of 8 days 11 hours 9 minutes and 8 days 11 hours 25 minutes respectively; while from New York to Queenstown, the former, in eighty-one voyages, shows an average of 8 days and 39 minutes, and the latter, in eighty-two voyages, an average of 8 days and 5 hours and 3 minutes; all these voyages being comprised within the same period of time."

Designs for the new Teutonic and Majestic were prepared by Sir Edward Harland so long ago as 1880, but the owners held their hands until 1886, when, the conditions of the trade having undergone considerable change, it became necessary for the new ships to be proceeded with, unless the company was prepared to see itself dropping behind its competitors. Negotiations were therefore entered into with the Admiralty, and arrangements made for the Teutonic and Majestic to be specially constructed for service as mercantile armed cruisers, and they are the first merchant steamers so specially constructed and retained under Admiralty agreement. The Teutonic was launched on January 19, 1889, her keel having been laid in March, 1887, twenty two months previously, and it was not until August 7, 1889, that she left Liverpool on her maiden voyage to New York, after astonishing nautical critics with her splendid proportions at the naval review at Spithead, where she was honored by a special visit of the German Emperor and the Prince of Wales. She crossed from Queenstown to New York in 6 days 14 hours 20 minutes, then the quickest maiden voyage on record. The Majestic was launched on June 29, 1889, and did not start on her maiden voyage until April 2, 1890. She still further lowered the record of maiden voyages, crossing from Queenstown to New York in 6 days 10 hours 30 minutes. Both vessels have during the past season given evidence of their great speed, as the figures in the table will testify.

Passages R. M. S. Teutonic and Majestic (White Star Line).

Steamer.	Date.	Passage.	Distance.	Speed.	
	1890.	D. H. M. Queenstown	No. of knots. n to N	Knots per hour ew York	
Teutonic.	July	5 21 55	2838	19·99	
	Aug.	5 19 5 (Fastest	2806 on re	20·18 cord.)	
"	Sept.	5 20 54	2774	19·69	Daily runs: 473, 496, 512, 500, 485, 340 = 2,806 knots.
"	Oct.	5 22 19	2779	19·53	
		New York	to Que	enstown	
"	Sept.	5 23 34	2794	19·46	
"	Oct.	5 23 54	2783	19·34	
		Queenstow	n to N	ew York	
Majestic..	July	5 22 58	2842	19·87	
"	Aug.	5 22 21	2784	19·56	Ten voyages averaging 5 days, 22 hrs. 10 mins.
"	Sept.	5 21 20	2780	19·67	
		New York	to Que	enstown	
"	Sept.	5 23 16	2810	19·61	
		Queenstow	n to N	ew York	
"	April	6 10 30	2829	18·31	Fastest maiden voyage on record.

But it will be seen that in these ships everything has not been subordinated to speed, when it is mentioned that their carrying capacity is such that in the event of the Suez Canal being closed they are capable of steaming from Portsmouth to Bombay *via* the Cape, a distance of 10,730 miles, in twenty-two days, without coaling on the way. The Teutonic and Majestic are the only two vessels now in existence possessing anything approaching such capacity. The length of time occupied in building these great ships is sufficient evidence, if any were needed, of the great care bestowed on their construction, and the builders, Messrs. Harland & Wolff, of whose firm Sir Edward Harland, Bart., is the principal partner, have their reward in witnessing the successful work which is being performed by the two finest vessels the world has ever seen.

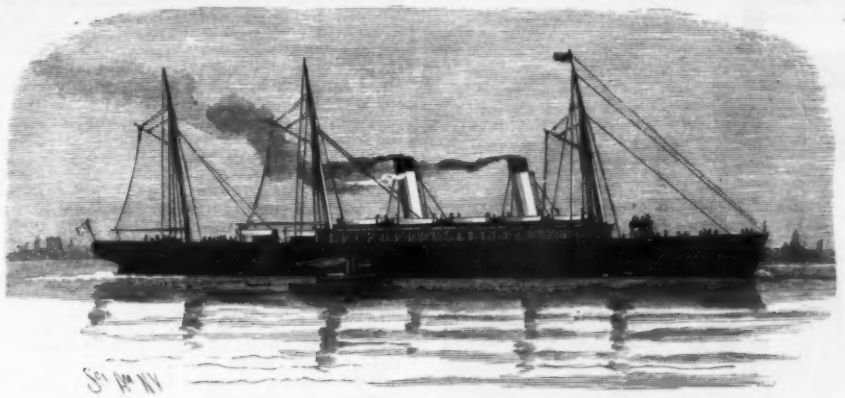
The following table supplies the needful particulars of the White Star fleet. It is interesting to note in this table the great difference between the additions made in 1874 and 1875 and those of 1889 and 1890. The Teutonic and Majestic are each double the tonnage of their immediate predecessors, while the engine power is three times as great.

The White Star Fleet.

Steamer.	Gross tonnage.	Indicated horse power.	When built.
Majestic	10,000	17,000	1890
Teutonic	10,000	17,000	1889
Britannic	5,004	5,000	1874
Germanic	5,008	5,000	1875
Adriatic	3,887	3,600	1872
Celtic	3,867	3,600	1872
Ionic	4,753	2,800	1883
Doric	4,784	2,800	1883
Coptic	4,448	2,600	1881
Gaelic	4,205	2,500	1885
Belgic	4,211	2,500	1885
Oceanic	3,807	2,000	1871
*Cufic	4,639	1,330	1888
*Runic	4,649	1,330	1889
*Nomadic, *Tauric, †Magnetic	Building.		

* Cargo and cattle steamers. † Passenger tender.

The dimensions of the Teutonic and the Majestic are: Length, 582 feet; breadth, 57 feet 6 in.; depth, 39 feet 4 in. The ships are built of Siemens-Martin steel, and propelled by two independent sets of triple expansion engines driving twin propellers, with manganese bronze blades. In addition to being minutely subdivided by athwartship bulkheads, they are constructed with a longitudinal bulkhead running fore and aft throughout the greater portion of their length,



THE WHITE STAR LINER TEUTONIC.

which gives additional rigidity to their structure, and greatly increases their security in the event of accident. They are each 4,244 tons net register, and can carry 855 fore cabin passengers, 175 second class, and 300 in the saloon. When fully loaded each will have on board about 3,000 tons of coal and nearly 4,000 tons of cargo.

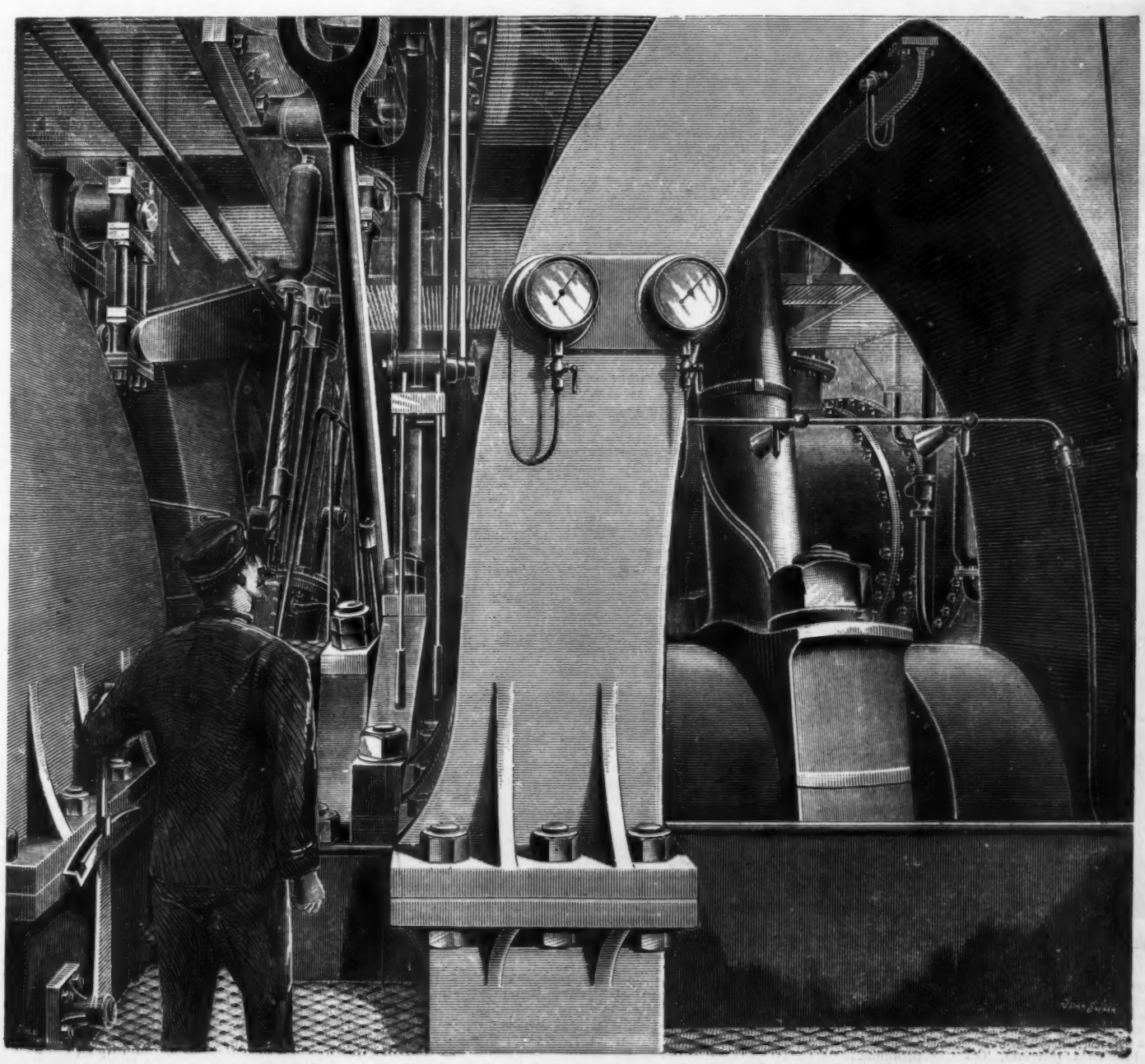
In the engine and boiler rooms each carries twenty-five engineers; Mr. T. Sewell, in the Majestic, and Mr. Currie, in the Teutonic, hold the extremely responsible positions of engineers-in-chief. There are sixty firemen and forty-eight coal trimmers; electricians, ice machine men, etc., bring up the engine room staff of each to one hundred and sixty-eight. They carry crews of about forty sailors, twenty-five cooks, and sixty stewards. Thus, when they go to sea they may have on board, with passengers, all told, about 1,600 souls. The Teutonic is commanded by Lieut. P. J. Irving, R.N.R., the Majestic by Lieut. H. Parsell, R.N.R.

The hull of the Teutonic has been constructed on a system which, if not absolutely new, has not before, so far as we are aware, been adopted in large Atlantic steamers. In the normal method of building, the vertical joints of the skin plating are made up with single butt straps inside, double, single, or treble riveted, according to circumstances. The rivets are in single shear, and it is well known that there is a tendency to open manifested by the joints. To get over this objection the builders of the City of New York and the City of Paris used double butt straps on the vertical joints, thus putting the rivets in double shear and getting great strength. The external appearance, however, of the hull is spoiled, and there can be no doubt but that the external straps tend powerfully to retard the progress of the ship through the water. Messrs. Harland & Wolff unite the ends of the plates by simple lap joints, the most forward plate always lapping over the plate next sternward, so as to prevent increase of resistance. The joints are treble, quadruple, and in some plates quintuple riveted. The skin plates were made by the Steel Company of Scotland—most of the beams being by Dorman, Long & Co.—and are of unusual dimensions, being 24 feet long and 3 feet wide. We have here a remarkable contrast with the old Atlantic steamer Persia, built more than thirty years ago, which had not a plate in her hull more than 6 feet long, the normal width being 24 in. At that time, and for some years subsequently, no ironmaster would supply plates of more than 400 cwt. without demanding an extra price. The hulls of the Teutonic and Majestic are cut up into sections by water-tight compartments in a way to secure the maximum of safety, and all the doors can be closed from the flying deck by pulling small wire rope lines, which release hooks holding the doors up. The descent of the doors is controlled by cylinders containing glycerine; and there are automatic arrangements by which the doors will close of themselves if the water rises unduly in the bilges.

It is, of course, impossible to exaggerate the importance of the steering gear in a ship like the Teutonic. The most elaborate precautions have been taken to secure immunity from breakdowns. The arrangements are novel in design, and covered by patents secured by Messrs. Harland & Wolff. In its main features it resembles a great horizontal spur wheel, 18 feet in diameter, movable round the rudder head. This wheel is connected to a tiller, keyed on the rudder head, by arms, each of which is made up of a layer of flat springs. The object of these springs is to take up the blow of a sea, and so relieve the gear of the excessive shock to which it would otherwise be subjected. The spur wheel is actuated by specially designed steam steering engines, constructed by the Harrison Patent Steam Steering Engine Company, Salford, in duplicate. The tiller wheel and brake gear are all built up of cast steel, and are thoroughly in character with the rest of the ship. Rhatjen's composition is used for coating the hull. All the steam winches, which are very massive, have been made by Messrs. J. H. Wilson & Co., Sandhills, Liverpool.

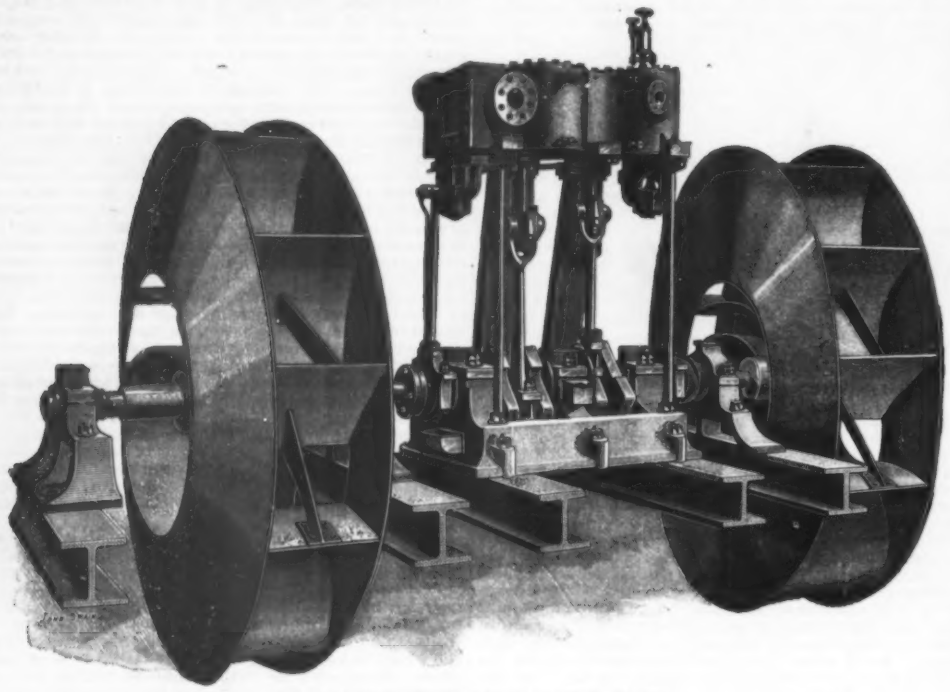
In the Teutonic and Majestic everything that art and science can do has been done to render the ship beautiful, luxurious, and safe. The general arrangement of the promenade and after decks will be gathered from our view of the ship when under steam. The library is placed immediately above the saloon amidships. The "skylight" for this last, rising through the floor of the library, forms a vast table of ground glass. We cannot do better than to reproduce here the description of the interior of the ship supplied by her builders.

In the general deck arrangements the characteristics

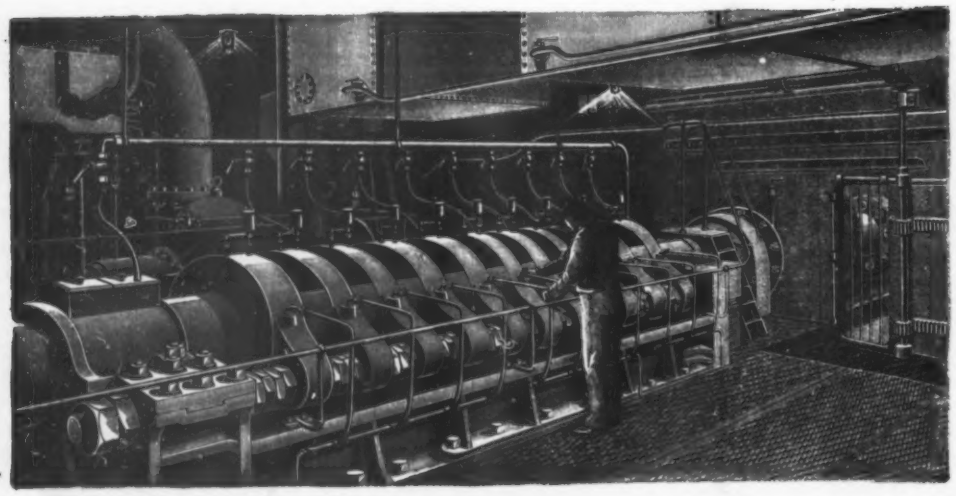


STEAMSHIP TEUTONIC—STARBOARD ENGINES, STARTING PLATFORM.

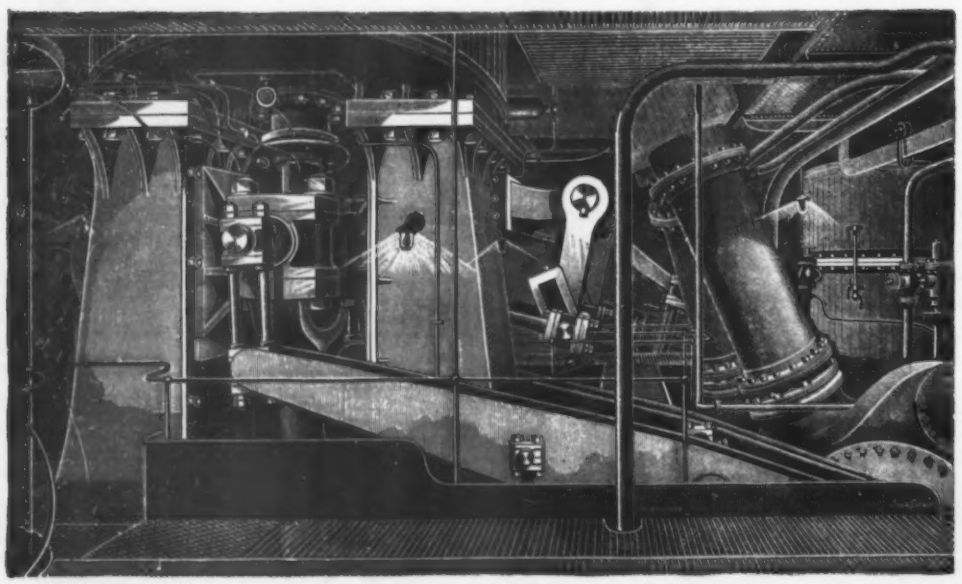
which have so long successfully prevailed, and which the White Star line were the first to introduce, are but little changed, while each class of passengers will find that nothing has been left undone which experience and forethought could suggest for their comfort. In the Teutonic and Majestic the saloon and sleeping accommodations have been placed in the very middle of the ship, where there is the minimum movement. The



STEAMSHIP TEUTONIC—DECK FANS.



STEAMSHIP TEUTONIC—STARBOARD THRUST BLOCK.



STEAMSHIP TEUTONIC—STARBOARD ENGINES, MIDDLE PLATFORM, LOOKING FORWARD.

hurricane and promenade deck is 245 feet long, with a clear width of 18 feet on each side of the deck houses, and is free of all obstruction, the boats being placed on an awning deck on top of this again, which serves as a permanent shelter in place of the canvas hitherto used for that purpose. On the promenade deck, besides the usual accommodation for the commander, there are good state rooms for passengers' use having direct communication with the deck below.

The companion way becomes a grand staircase, leading to the promenade deck. The steps and walls are composed entirely of selected English oak, which, as it becomes tempered and mellowed with age, assumes a darker and richer hue, until it nearly resembles black walnut. It is the same style of oak that for centuries has made England famous in her wainscotings in abbeys and manor houses. The stairs are wide, spacious, and gradual in descent, terminating in a broad, substantial landing, which is relieved by an inlaid, tinted rubber floor that contrasts pleasingly with the shades of oak. The balustrade is highly polished, massive, and relieved by a deep beading. The upright rounds are correspondingly heavy, fitting into side pieces that are hand carved in a beautiful pattern of bass relief. The newel posts are heavy, finely polished, and handsomely carved; while strong supporting pillars, bearing a special pattern, with the heads of Tritons added to the quaintly wrought paneling of the walls, complete the structure.

The library is on the promenade deck. The great central table is of ground glass, as already explained, giving light to the saloon below. It is a large and cheerful apartment, with nooks and corners in which it is easy to find comparative seclusion. It is paneled throughout in light oak, carrying a novel ornamentation produced by burning the design into a gilt ground, relieved by finely worked carvings and hand made panels in varied colored crewels on a pale blue satin ground. The room is lighted at the sides by windows covered with shutters of Italianesque design, that admit a subdued light. Additional light is furnished by the stained glass dome. Every device and appliance that could possibly add to the comfort and luxury of the inmates have been furnished. Revolving chairs, that, while inviting rest and contentment, occupy but little space, are here found in conjunction with small separate writing tables. The library is the only general room on the promenade deck, and is entered from the main entrance to the saloon. This main entrance and the two flights of staircase, with four solitary exceptions, lead to all the staterooms.

The grand saloon seems to have been built of ivory, relieved with gold. It is situated just about the mid-length of the ship, where the motion is least. The walls are mounted in ivory enamel, relieved by a delicate and elaborate tracing, slightly shaded with a filling of gold, while the panels in this labyrinth of artistic design, wrought in a glyptic material, exhibit Tritons, sea nymphs, and other ocean symbols, all gracefully grouped and executed. The figures in relief are finished in an ivory-like surface, and the groundwork of the panels is of gold, The ports are lined with dark *repoussé* brasswork of the same Renaissance character as the walls, and are fitted with stained glass shutters, emblazoned with the arms of the different States and cities of America, Canada, and Europe, behind which are placed electric lights, so that the brightness of the design is apparent by night or day. The decoration of the ceiling corresponds with the walls in the tints of ivory and gold, the electric lights peeping forth from numerous niches and artistic corners. Tables of polished wood extend the entire length of the saloon, flanked on either side by revolving chairs. There are in all 300 chairs, and, as the Teutonic only carries 300 first class passengers, the annoying relay system of dining has been avoided. Light is supplied through the stained glass dome as well as through the side ports.

The smoking saloon is the most luxuriously fitted apartment of the kind to be found anywhere. It is fitted with several "boxes," if we may use the word, in which parties of six or eight can isolate themselves to a certain extent. The walls of this room are covered with richly gilt embossed leather, the design being a careful reproduction of one of the best patterns of the old Flemish *cuir repoussé*. Panels in the sides of the room are decorated with admirable oil paintings, representing shipping from some of its most picturesque and interesting aspects. 1 Represents the Spanish American Empire, a royal treasure ship in the seventeenth century, by E. J. Taylor; 2, armed Genoese galley in the harbor of Venice, sixteenth century, by Frank Murray; 3, Columbus in sight of America, representing the Nina, Pinta, and Santa Maria, in October, 1497, by Frank Murray; 4, the Romans in Britain during the second century, by E. J. Taylor; 5, Viking ships in the Nile during the tenth century, by Frank Murray.

Other spaces are filled with shallow niches, each containing a figure in high relief, carved in pearwood, after Donatello. The dome and ceiling are works of art in themselves, the latter containing an old English plaster pattern in oddly shaped panels, with finely modeled rosettes at intervals. Shutters of stained and ornamented glass fit each window, and are placed in position as soon as the electric lights are called into requisition, completely obscuring the inmates from all outside observation. The floor of this apartment, like that of the vestibule at the foot of the grand staircase, is a novelty, and a decided improvement on anything of the kind that has heretofore been introduced. It is composed of rubber, inlaid and artistically colored and arranged in pleasing designs and patterns. The superiority of this over a wood floor, or one covered with oilcloth, linoleum, or even the finest carpet, is obvious, as to slip on a rubber floor, when the ship pitches or rolls, is well nigh impossible.

The White Star steamers sail, under contract with the British government, from Liverpool every Wednesday with her Majesty's mails for the United States. The hour of embarkation is regulated by the tide, but no later embarkation takes place than 4 P. M. Only a portion of the mails is put on board at Liverpool, the bulk being conveyed by the Irish mail train leaving London on Wednesday night at 8:20, proceeding by steamer from Holyhead to Dublin, and reaching Queenstown on Thursday at 12:15 P. M., where the steamer usually arrives early the same morning and waits for the mails and such passengers as may accompany them. The steamer gets away from Queenstown at about 2 P. M. on Thursday afternoon, and a six day passage brings her into New York and allows of passengers landing there during the forenoon of the following Wednesday.

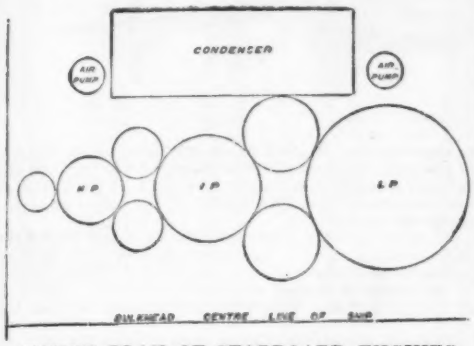
At New York the steamer lies alongside the pier, which projects into the river at right angles with the street, and passengers are able to walk straight from the shore on board the ship. The departure from New York, as from Liverpool, takes place on Wednesdays, and the hour of embarkation is regulated by the tide. On the return voyage the steamers use American coal, some of the finer qualities of which are equal to the best English coal.

The second cabin accommodation in the Teutonic and Majestic is equal, and in many respects superior, to what was afforded to saloon passengers a quarter of a century ago, the rooms being larger and more conveniently fitted. The steerage accommodation is also a great improvement on anything previously attempted. A special feature in this department is the shelter provided on the upper deck. The saloon promenade deck extends a distance of 245 ft. over both sides of the upper deck, and thus gives, with the high bulwarks, excellent sheltered promenades for steerage passengers, for whom ample seat accommodation has also been provided.

The Majestic and Teutonic are capable of conveying 2,000 troops to any part of the world without coaling on the way, and are in every respect admirably adapted for the carriage of troops. It only remains to add that both ships have been built without bargaining or specification. The White Star Co. gave Messrs. Harland & Wolff the order for the best ships they could build, without limiting them in price.

THE MACHINERY OF THE TEUTONIC.

The Teutonic and Majestic are propelled by twin-screw, triple-expansion engines, indicating about 17,000 horse power. The numerous views which we publish will convey an idea of the impression which



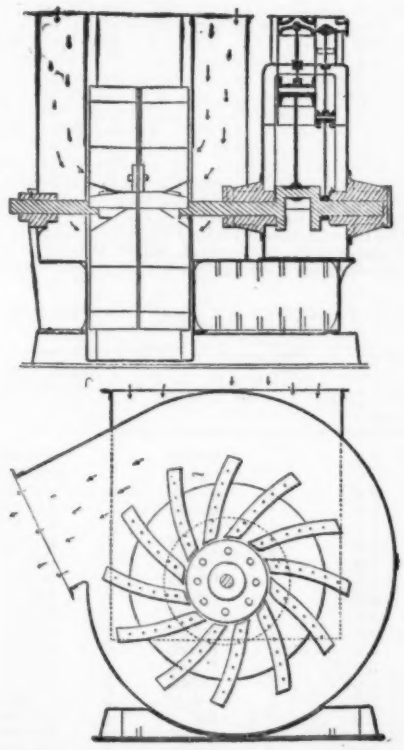
SKETCH PLAN OF STARBOARD ENGINES.

these enormous machines make on the mind of even those familiar with marine engines.

The general arrangement of the engines will be gathered from the accompanying sketch plan, which it will be understood is not drawn to scale, but will serve to illustrate the general arrangement of each engine room.

The cylinders are 43 in. + 68 in. + 110 in. × 60 in. The high pressure cylinders stand next the boiler rooms. The engine rooms are over 50 ft. long. All the cylinders have piston valves, two each to the intermediate and low pressure cylinders, and one to the high pressure cylinder. The cylinders are not steam jacketed, a very extended experience serving to convince Messrs. Harland & Wolff that nothing is to be gained from jacketing, at sea at all events, unless the steam is permitted to blow through the jackets so as to be constantly renewed. This can only be done in a way to avoid much waste and loss with great difficulty. All the cylinders of the Teutonic are, however, fitted with liners and are air-jacketed. The intermediate and low pressure pistons have tail rods, but the high pressure pistons have not. All the pistons are coned to impart stiffness, and have been made as light as is consistent with strength.

Each cylinder is carried on cast steel frames. In front is an A frame, and at the back a single frame, so that the cylinders are carried each on three points of support, and the "three-legged-stool" principle is called in to give stability, which it does in the fullest degree. The condenser is quite separate from the engine. It is cylindrical, of brass, some 20 ft. long, and 7 ft. in



CHANDLER ENGINES AND FANS.

diameter. The tubes are of brass, ⅝ in. diameter. The aggregate length of all the condenser tubes is about twenty miles. The water passes through the tubes three times; it is supplied by vertical centrifugal pumps by Messrs. Tangyes, of Birmingham. There is an air pump at each end, worked by back levers by the high and low pressure engines. These levers also actuate the bilge and sanitary pumps. The boilers are fed by Weir's vertical pumps, but Worthington pumps are also provided.

The engines are separated by the longitudinal bulkhead, which rises a few feet above the water line to a point about level with the cylinder covers. The whole of the upper part of the engine room is common to both engines. As the propellers overlap, the engines can be placed much closer together than is possible when the usual system is adopted, and the arrangements of the engine rooms are exceedingly good. Access is obtained by winding stairs of ample proportions, which are a vast improvement on ladders. The engraving on first page is a view taken at one end of the upper platform, the cylinder covers appearing on either hand—to port and starboard. The engine room is about 50 ft. long.

The valve gear is of the ordinary Stephenson shifting link type. The rods of the two sets of piston valves on the intermediate and low pressure cylinders are keyed into a crosshead working in guides, and to the center of the crosshead. The link die is coupled so that one link serves for both valves. We give a view taken on the middle platform. The cylinder bottoms are seen overhead. The construction of the valve gear will be readily understood. The hand wheel and screw on the weigh shaft is for fine adjustment for expansion.

We give a view taken on the lower platform, which gives a good idea of the enormous dimensions of the crank shaft and connecting rods. The Brown hydraulic reversing gear is shown to the left hand side. The crank shafts, each weighing 41 tons, are of Whitworth steel, the crank pins being 22 in. by 22 in. The main bearings are not of extravagant length. Indeed, they look short, but it is a noteworthy fact that they have never yet needed a drop of water on them, or heated in the slightest degree to give trouble.

We give a view of one of the thrust blocks, which stand in a conveniently large open space abaft the engines, and under the platform on which are two powerful electric light engines by Messrs. Tangyes, driving dynamos by Messrs. Crompton, of Chelmsford, who have carried out, as described further on, all the electrical arrangements throughout.

We have already explained in a previous issue that the screw shafts are placed so close together that the screws overlap 5 ft. 6 in., and the starboard propeller is astern of the other by 6 ft. The propellers revolve "outboard." A large opening is made in the dead wood to allow of this system of construction. There are no stern brackets, the hull being worked out round the screw shaft, and fitted with a strong spectacle casting in steel, which carries the stern bearings. There is no screw alley in the ordinary sense of the word. Each screw shaft—one 199 ft. and the other 205 ft. long, weighing 76 tons—runs along a species of chamber which, well aft, is really outside the hull. One of our engravings shows a view taken in this chamber. At the other side is the longitudinal bulkhead, and in the space between this and the shaft are placed ice-making machines—ammonia—by Sulzer, of Winterthur, and the cold air storage holds are supplied with cold air by fans from this department. Everything is duplicated, so that the machinery at both sides of the bulkhead is the same.

The screw propellers are 19 ft. 6 in. diameter and 28 ft. 6 in. pitch, four bladed, modified Griffiths' true screws, with a surface of 108 square feet each. The propeller blades were cast of Parsons' manganese bronze from ingots supplied by the Manganese Bronze and Brass Co., Deptford, by Messrs. Harland & Wolff, Belfast, who have for some time past adopted this metal for the propellers of all their fast passenger steamships with satisfactory results as regards speed and economy, and in order to turn out these castings in the most perfect manner, have spared no expense in erecting suitable furnaces and providing special plant for the purpose. The engines make from seventy-nine and eighty-two revolutions when driven as fast as they can go. On an Atlantic voyage, the average for the whole run is about seventy-eight revolutions per minute.

Steam is supplied by twelve double ended and four single ended boilers, containing eighty-four furnaces. The pressure is 180 lb. They are worked with forced, or rather assisted, draught, on a modification of Howden's system. On the bridge decks, at each side of the funnels, there are four double fans, driven by compound engines, which we illustrate. These have been supplied by Messrs. Allen & Co., engineers, York Street, Lambeth. They drive air into the stokeholds, supplementing the supply drawn through the fiddley gratings. Below these are fourteen fans, driven by Chandler engines, and constructed by Messrs. Bumpstead & Chandler, Hednesford, Staffordshire. These fans are double, and 5 ft. in diameter. Each fan—of which there are fourteen in each ship—is able to pass about 16,000 cubic feet per minute at a plenum of 3 in. of water, the revolutions being 350 per minute. The fans give from their construction a high efficiency relatively to the blade tip speed, and up to date have worked to the entire satisfaction of all concerned. Our illustration shows one of the fans and engines combined. They draw the air from the hottest places in the stokeholds and force it into chambers in the uptakes at the bases of the chimneys.

There are fifty vertical tubes in each chamber, and through these tubes the products of combustion pass, while the air from the fans circulates round them, and passing down the sides of the smoke boxes is finally delivered into the closed ash pits at a temperature of about 250°. About one-fourth of the whole air supply is admitted over the fires. The combustion is very perfect, and it is only under exceptional circumstances before the fires are fairly away that such a volume of smoke as that seen in our engraving is given off. The chimneys, two in number, are oval, each 14 ft. on the major axis by 11 ft. 6 in. wide. In addition to the eighteen fans we have named, three others, two for keeping the dynamo rooms cool and one for ventilating the firemen's quarters, are fitted.

(To be continued.)

To find out the amount of slack given to cables as deposited in the ocean at the time of paying out, Messrs. Siemens Brothers are using a steel piano wire, payed out simultaneously, with a tension sufficient to make it taut over sea bottom. By mechanism on board, which measures the rate of paying out cable and wire, the necessary slackness in the cable can be determined and constantly verified, thus avoiding all unnecessary slackness and saving large sums of money.

NEW METHOD OF VENTILATING TUNNELS.

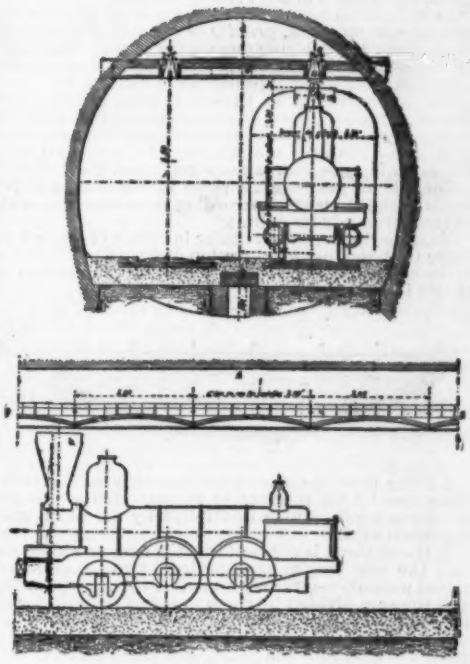
MR. L. POCHET, government engineer, has recently devised a new system of aerating railway tunnels which he proposes to apply on the Metropolitan Railway of Paris. In this system the steam and gases that escape from the locomotive stack are separated and expelled mechanically.

The system consists in dividing the tunnel into two chambers by a horizontal partition, *p p* (see figure), placed at a distance of 15 feet above the rails. This partition contains two continuous longitudinal flues. These flues, which converge toward the top, are closed by balance valves, *c c*, that open upwardly. The upper or smoke chamber receives the steam and the gases of combustion that are thrown into it from the smoke stack of the locomotive. In order to assure of the introduction of the gaseous fluids into the flues, the smoke stack, instead of having the ordinary cylindrical form, slants upwardly to a bevel angle.

The smoke chamber communicates every half mile with a suction ventilator, which extracts the air from the chamber and forces it into a chimney of proper height above the roofs. This chimney will be placed in the yard of a house situated on the public street, and will be connected with the smoke chamber of the tunnel by a gallery from 75 to 150 feet in length.

In consequence of these arrangements, the tunnel properly so called receives neither gas nor steam. The upper chamber, which is tight, by reason of the automatic closing of the valves, retains them entirely. On another hand, as the ventilator is in constant operation, even in the interval between the passage of trains, there is produced a slight suction which tends to lift the valves, and which brings about a certain renewal of the air in the tunnel. In other words, the air of the tunnel remains perfectly pure.

The smoke chamber is of sufficient dimensions to allow a man to traverse it with a small wagon during the night, while the line is not in operation, in order to remove the ashes and soot, clean the valves, and keep all the movable parts in a proper state of repair.



POCHET SYSTEM OF VENTILATING TUNNELS.

According to Mr. Pochet's calculations, and for an hourly passage of forty trains, it is thought that the volume to be extracted by the ventilator per hour and per mile of tunnel will amount to 175,000 cubic feet, half of which consists of air carried along by the exhaust of the locomotive. This volume is ten times less than that that has to be extracted from the Liverpool tunnel, in which, moreover, there is an hourly passage of but twenty-four trains.

In the system under consideration, the motive power necessitated by the running of the ventilator will be 20 horse power per mile, while in the system of direct ventilation the power would be that of 120 horses.

It is to be remarked that the power to be developed increases greatly with the number of the trains. In fact, the power is proportional to the delivery of the air to be extracted and to the square of the velocity of the air in the various conduits that it flows through. This velocity is itself proportional to the delivery. Consequently, the power to be developed is proportional to the cube of the delivery, or to the number of trains per hour.

If it requires 60 horses for 40 trains, it will require for 60 trains—

$$60 \times \left(\frac{60}{40}\right)^3 = 203 \text{ horses.}$$

It may be concluded from this that the system of direct ventilation would ventilate only incompletely as soon as the ventilation of the trains for which it had been provided had increased somewhat. This is something that will daily occur on the Paris Metropolitan, where the number of trains will vary greatly according to the hour of the day and the days of the year. The Pochet system has not the same inconvenience. Always in operation, the ventilator will be all the time exhausting the same volume of gas, even though the number of trains chances to increase. It will simply happen in this case that the proportion of air contained in the volume of gas will diminish in measure with the increase of the number of trains. —*Le Genie Civil.*

THE POWER OF WATER, OR HYDRAULICS SIMPLIFIED.

By G. D. HISCOX.

MEASUREMENT OF THE FLOW OF STREAMS.

WATER power will be sought, utilized and economized in all countries wherever fuel becomes expensive or scarce, and is now the only recourse for power in many of the mining regions of the United States, Mexico and South America.

The utilization of the water of the arid districts of all countries for the purposes of irrigation and power has long been a necessity in the older countries, and will soon become, if not now, of the utmost importance as the tide of population covers the great plains of our Western hemisphere, and to this end the necessities of human existence require the utmost economy in utilizing this great element in nature that is so essential to our being.

The flow of water in streams and the measurement of the power that may be derived from its mechanical transmission into work, in a form that may be understood by persons not versed in mathematics or engineering expedients, is a much desired want with many people who have water power to develop and are unable to obtain the service of experts for the solution of a preliminary or uncertain problem.

For such we will endeavor to make the problems appertaining to the flow and power of water of easy solution by any one with ordinary arithmetical tact.

The numerical value of the power of water as a natural mechanical agent is derived from three elements, namely, gravity or weight, height or pressure due to height, and volume of flow, against which, form of ajutage or orifice, friction and leakage or spillage are the coefficients that make a reduction in the realization of its full value.

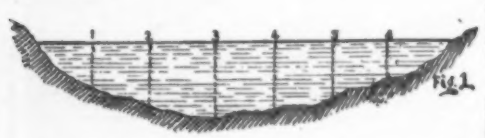
Descending fluids are actuated by the same laws as falling bodies for all the practical purposes of computation, and by virtue of their vertical fall descend 16·08 feet in the first second and attain a velocity at the end of the first second of 32·16 feet per second.

As one second is assigned as the unit of time in hydraulic computations, *gravity* or the velocity attained by a falling body during one second of time becomes a symbolic expression of which the letter g is always the exponent, and which represents the value 32·16.

The measurement of the mechanical effect of the flow of water in streams or over dams may be obtained from a few observations, beginning with the measurement of a quiet section of a stream in a general way, for obtaining the approximate volume of flow.

For this purpose select a place in the stream a few yards or rods in length, according to its size, where the channel is nearly straight.

Measure the depth at regular intervals of space from shore to shore, making a section of from 6 to 12 or more divisions, according to the width of the stream, as shown in Fig. 1.



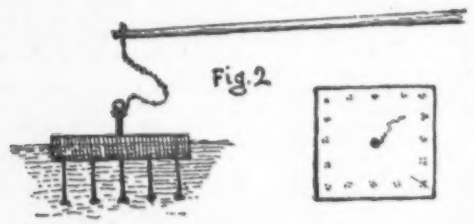
Adding these measurements together and dividing their sum by the number of measurements will give the mean depth, which multiplied by the width gives the mean area.

If the channel is not uniform for two or three rods and the best results are required, two or more sectional measurements may be made, their means added and the sum divided by the number of sections for the mean of the range.

All the measurements should be made in feet and tenths of a foot for convenience of computation.

If measured in inches, the change is readily made by multiplying the measured inches by 10 and dividing by 12.

The velocity of the stream may then be taken with a float made of a small block of wood three or four inches square, with nails driven into the under side, and a nail in the center of the upper side for observation, as in Fig. 2, and to which a string attached to a



rod will make a convenience in handling. A fishing pole with bob and sinker answers every purpose for small streams.

A measured distance of from 10 to 50 feet on the center line of the stream should be made by driving stakes on each side of the stream, or setting a very thin stake near the center, if accessible.

The float or bob being dropped into mid-current just above the upper line of sight or stake, the moment of passing the line is noted to the nearest second, and the time of passing the second line or stake also noted to the nearest second. This may be repeated, as the mean of two or more observations makes the work more reliable.

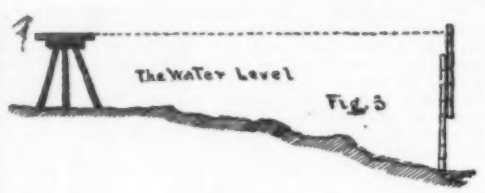
The distance in feet between the two marks or stakes divided by the number of seconds gives the number of feet and decimals of a foot as the velocity of the center line of the surface of the stream.

From this should be deducted 10 per cent. for friction of the bottom and sides of the stream or channel when of a depth equal to one third of their width, if the bottom is smooth, 15 per cent. for rough, stony bottoms, and 20 per cent for very shallow streams with rough bottom.

The corrected velocity of the stream in feet per second, multiplied by the corrected sectional area, gives the volume of water in cubic feet per second.

If a dam or any obstruction is to be made in the stream for the purpose of obtaining a fall, a carpenter's level, or if not at hand, a water level may be improvised and set up at the proposed site and height of the dam, so ranged that the fall may be measured at any desired distance down stream and the back water line of the proposed dam observed and staked.

The water level, Fig. 3, may be made of a board four



inches wide by two feet in length, planed straight upon the edges and slightly concave in the center and oiled. It should be laid upon another flat board, which may rest upon a pile of stones, or on stakes, so arranged that it may be leveled by wedging up the under board. A little water in the slightly hollowed part of the upper board showing an approximate level suitable for mill engineering.

This arrangement will allow the level to be swept around, up, down or across the stream for observation.

A pole with its foot set at the water's edge at any point down stream may be observed by the eye along the upper edge of the water level, and the level height marked by a second person by shoving a stick up to the point of sight, and thus obtain a measure reliable for all practical purposes.

The cubic feet of water flowing per second multiplied by its weight per cubic foot (62·5 lb.) and this product multiplied by the observed height in feet gives the number of pounds falling one foot per second, which, divided by 550, gives the horse power of the stream.

To make this plainer to the mind of the amateur, the following example is given :

Let the measurements be taken as described for Fig. 1 at

2′ 4″	
3′ 8″	18′ 9″ = 18·75′ / 6 = 3·235 mean depth.
3′ 9″	Let the stream be 50 feet wide, then 50×3·225
4′ 3″	=161·25 square feet area.
3′ 3″	Let the surface velocity, as found by several
2′ 6″	measurements, be 40 feet in 20 seconds, or 2 feet
	per second, with a fairly smooth bottom, for
18′ 9″	which we deduct 10 per cent., making the mean

velocity 1·8 feet per second. Then 161·25×1·8=290·25 cubic feet. Let the observed fall that can be had equal 10 feet.

Then $\frac{290·25×62·5×10}{550}$=329·8 horse power as the value of the stream.

From this 35 per cent. should be deducted for loss of head by the flume, leakage, and the coefficient of the best water motors, which leaves for work 247 horse power. If an ordinary water wheel is to be used, not less than 40 per cent. should be deducted from the gross power of the stream.

Allowance should also be made for the water stage of a stream at the time of measurement, so that a computation for the average of a season may be made.

The back water of a dam is of some value, if it can be made large enough to be made available on small streams, when the power required is nearly equal to the flow. The proportions for increase of back water service in large streams where the full power is utilized become enormous, as a few figures will show.

For the above stream the constant flow for 10 hours is 290·25×36,000 seconds = 10,449,000 cubic feet for a gross power of 329·8 horse power.

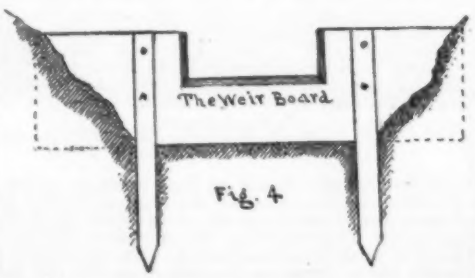
To increase this power 10 per cent. by impounding the night flow will require an area to hold 1,044,900 cubic feet of water, or the raising of the dam one foot, and with a pond area 200 feet wide by 5,224 feet or nearly one mile long. Hence the utility of storage of water for power purposes is a useless expense, except where the natural conditions greatly favor it.

The raising of the water head or dam 10 per cent. is expensive, in proportion to the gain; and, finally, the most effective way to do more work with water power is to extend the running time to 11 or 12 hours, or making 2 shifts of 8 or 10 hours each per 24 hours, as is so much in practice among our great mills using water or steam power.

MEASUREMENT OF FLOW OVER WEIRS.

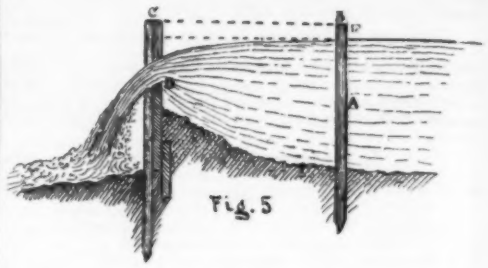
The method of weir measurement is more suitable for small and rapid streams, mountain torrents and springs.

For this purpose a rough estimate of the size of the weir must be made to enable you to make it ample to pass the whole stream. A small weir may be made by a simple rectangular notch in a board, which for convenience of measurement may be 8 to 10 times wider than the depth. Bevel the edge of the notch toward the down stream side of the weir, as shown in Fig. 4.



Set it across the stream so that the bottom of the notch shall be level; holding the board in position by stakes or stones, and packing the under side and ends with any convenient material—as gravel or sand—and tightening by a layer of loam.

Drive a slender stake at A, Fig. 5, two or three feet up stream from the weir, and on one side of the notch,



so that the top, B, shall be exactly level with the top of the weir board at C. The filling at the back should be kept a few inches below the spill at D, Fig. 4, to prevent obstruction or friction of the water as it approaches the spill.

When the stream pours over the weir, and the height at the stake E, Fig. 5, becomes stationary, measure the distance from the top of the stake at B to the surface of the water at E, and subtract it from the full depth of the notch C D. This will give the true depth of the spill.

As the slope of the water surface over the weir increases with the depth, caused by the velocity increasing as the water approaches the spill, makes a direct measurement at the spill an uncertain exponent in the computation of volume. Hence the necessity of leveling back to a stake in comparatively quiet water.

The leveling may be done with a carpenter's level on a straight edge, or by a water level, as before described.

The difference between the actual depth at the spill and the properly measured depth as above may vary from 0·9 to 0·75 of the stake measure.

A coefficient of correction for the slope and friction must be used which by experiment has been found to vary from 0·63 for 1 inch in depth to 0·58 for 24 inches in depth, so that, for all ordinary purposes, the coefficient C may be taken at 0·6. Then the equation for volume in cubic feet per second is

$$C\ \frac{2}{3}\ b, h,\ \sqrt{2\,g,\ h}$$

For example, with a weir 6 inches deep (h) and 4 feet wide (b), the equation becomes when applied :

$$0·6 \times \frac{2}{3} \times 4' \times 0·5' \times \sqrt{64·32 \times 0·5}$$

The square root of the last term

$$\sqrt{64·32 \times 0·5} = \sqrt{32·16} = 5·67$$

Then

$$0·6 \times \frac{2}{3} \times 4' \times 0·5 \times 5·67 = 4.536$$

cubic feet discharge per second. For the convenience of a more direct or easier computation, we give the following approximate table of depths in inches and decimals, with the corresponding depth in decimals of a foot, for depths up to one foot; which gives a close approximation for the flow in cubic feet per second, by simply multiplying the width of the weir in feet and decimals of a foot by the coefficient opposite to the measured depth of the weir as before described. Any measures between the depths given may be interpolated proportionately in all the columns. For example, with a weir as before, 4 feet wide by 6 inches deep, in the table opposite to 6 inches, or 0·5 of a foot, will be found 1.1295, which, multiplied by 4 feet, equals 4.518 cubic feet per second, which is near enough to the figures from the equation for all practical purposes:

WEIR TABLE FOR ONE FOOT IN WIDTH AND FOR DEPTHS UP TO ONE FOOT.

Depth Inches and Tenths.	Depth Decimals of a Foot.	Flow in Cubic Feet per Second for One Foot in Width.
0·4″	0·0333′	0·01365
0·6″	0·0495′	0·03408
0·8″	0·0666′	0·05452
1·0″	0·0833′	0·08022
1·2″	0·100′	0·10592
1·4″	0·1165′	0·13012
1·6″	0·1333′	0·16616
2·0″	0·1666′	0·22893
2·4″	0·200′	0·29171
2·8″	0·2333′	0·36825
3·0″	0·2498′	0·40653
3·2″	0·2666′	0·44480
3·6″	0·2995′	0·53795
4·0″	0·3333′	0·63111
5·0″	0·4165′	0·88030
6·0″	0·5′	1·12950
7·0″	0·583′	1·43795
8·0″	0·666′	1·74640
10·0″	0·833′	2·40040
11·0″	0·9166′	2·76770
12·0″	1·000′	3·13500

For further convenience we give the following weir table of larger scope than the one computed from the formula, which also gives a slightly larger volume, arising from the use of formulas for a different line of experiments, but near enough for all ordinary purposes.

It is arranged for depths of ⅛ inch to 24 inches, and for a width of 1 inch; so that simply multiplying the quantity in the table at the junction of the unit and fractional part of an inch by the width of the spill in

FLOW OF WATER OVER WEIRS FROM ⅛ INCH TO 24 INCHES IN DEPTH, FOR EACH INCH IN WIDTH, IN CUBIC FEET PER MINUTE.

Inches.	Even Inches.	⅛"	¼"	⅜"	½"	⅝"	¾"	⅞"
0	....	0·01	0·05	0·09	0·14	0·20	0·26	0·33
1	0·40	0·47	0·55	0·65	0·74	0·83	0·93	1·03
2	1·14	1·24	1·36	1·47	1·59	1·71	1·83	1·96
3	2·09	2·23	2·36	2·50	2·63	2·78	2·92	3·07
4	3·22	3·37	3·52	3·68	3·83	3·99	4·16	4·32
5	4·50	4·67	4·84	5·01	5·18	5·36	5·54	5·72
6	5·90	6·09	6·28	6·47	6·65	6·85	7·05	7·25
7	7·44	7.64	7·84	8·05	8·25	8·45	8·66	8·86
8	9·10	9·31	9·52	9·74	9·96	10·18	10·40	10·62
9	10·86	11·08	11·31	11·54	11·77	12·00	12·23	12·47
10	12·71	12·95	13·19	13·43	13·67	13·93	14·16	14·42
11	14 67	14·92	15·18	15·43	15·67	15·96	16·20	16·46
12	16·73	16·99	17·26	17·52	17·78	18·05	18·32	18·58
13	18·87	19·14	19·42	19·69	19·97	20·24	20·52	20·80
14	21·09	21·37	21·65	21·94	22·22	22·51	22·79	23·08
15	23·38	23·67	23·97	24·26	24·56	24·86	25·16	25·46
16	25·76	26·06	26·36	26·66	26·97	27·27	27·58	27·89
17	28·20	28·51	28·82	29·14	29·45	29·76	30·08	30·39
18	30·70	31·02	31·34	31·66	31·98	32·31	32·63	32·96
19	33·29	33·61	33·94	34 27	34·60	34·94	35·27	35·60
20	35·94	36·27	36·60	36·94	37 28	37·62	37·96	38·31
21	38·65	39·00	39·34	39·69	40·04	40·39	40·73	41·09
22	41·43	41·78	42·13	42·49	42·84	43·20	43·56	43·92
23	44·28	44·64	45·00	45.38	45·71	46·08	46·43	46·81
24	47·18	47·55	47·91	48·28	48·65	49·02	49·39	49·76

inches will give a near approximation to the volume of flow per minute.

In using this table of volume for computing the horse power of a stream, 33,000 should be used as a divisor in the formula, which becomes :

Cubic feet per minute × 62·5 *lbs.* × *height in feet* divided by 33,000 = the gross horse power of the stream.

From this quotient, 20 per cent. should be deducted for the available power that can be obtained by the best turbines and water wheels, although 85 per cent. is claimed by some makers.

(To be continued.)

LIEUT. FISKE'S POSITION FINDER.

IN a recent issue we described the valuable range finder of Lieut. Bradley A. Fiske, by which a gunner is enabled to know accurately the distance of the object which he is firing at. This instrument can be applied in many situations on land and on board ship, but presupposes, of course, that the gunner is able to sight directly upon his target. In modern fortifications, however, the tendency to the employment of what are known as disappearing carriages is becoming stronger every day, and hundreds of such carriages are already employed in the sea coast forts abroad.

In these forts the guns are loaded below the level of the parapet and when ready to fire are raised into firing position, usually by a hydraulic ram. This method of operation evidently protects those charged with the loading of the gun while the operation of loading is in progress ; but it is evident that by the means heretofore at hand, it has been impossible to sight the gun while depressed behind the parapet. True, the range could be determined beforehand by means of the range finder so as to permit the gun to be given the correct elevation before raising to fire, but this gives no indication of the true direction of the object to the concealed gunners, and hence deprives them of an essential factor in the pointing of the gun.

What was wanted, therefore, was some means by which the gunner could obtain both the range and direction of the object, with regard to the gun as a central point, in other words their relative position. It is this which Lieut. Fiske has now accomplished, and in virtue of which the gunner is enabled to locate on a chart, drawn to scale, the exact position of a distant object which he has no means of seeing, but which is being sighted on by two observers placed at any distance, well protected from the fire of the enemy and unobscured by smoke.

The new position finder may be said to be a simplification and amplification of the range finder. It embodies, first, a telescope moving over an arc of conducting material and which is directed upon the distant object ; second a pivoted pointer moving over a like arc of conducting material in a Wheatstone bridge circuit with the first named arc ; the arrangement being such that when the alidade arm attached to the telescope on the first arc and the pointer on the second arc stand at the same angle, the circuit is balanced. The pointer arm moves over a chart representing the

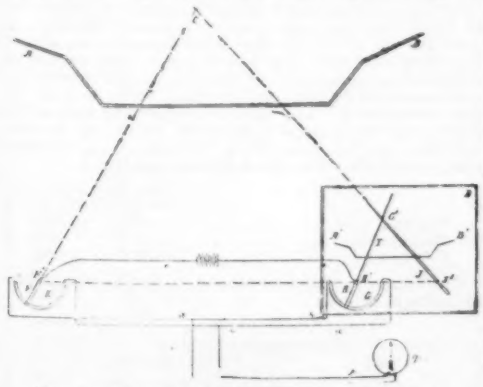


FIG. 1.—DIAGRAM OF FISKE POSITION FINDER.

area which includes the position of the distant object on a reduced scale. On this chart there is a simple pivoted arm, which can be trained directly upon the object ; or the arm may be mechanically controlled by a telescope directed upon the object, so that it will make with the other arm an angle equal to that made by the lines of sight drawn from the two telescopes to the object. The position of the object is then shown by the intersection of the electrically directed pointer and the mechanically directed arm upon the chart.

In the accompanying illustrations, Fig. 1 is a diagram showing the general arrangement, and Fig. 4 is a similar diagram showing the chart, D, in different position. A B represents, for example, the parapet of a fortification. The distant object is supposed to be located at C ; and it is the position of this object which is to be determined upon a chart, D, on which the fortification line A′ B′ appears on a reduced scale. E is an arc of conducting material and F a telescope or arm pivoted at one end at F′ with its free extremity moving over, and making contact with, the arc, E. G

FIG. 2.—FISKE POSITION FINDER IN USE.

is an arc similar in all respects to the arc, E, and located in proximity to the chart, D. H is an arm pivoted at H′ and having is free end sweeping over, and making contact with, the arc, G, and carrying a pointer, I. *a*, *b*, *c*, *d*, are members of a Wheatstone bridge connecting the arcs, E and G. E is a loop including the battery, and *f* the loop including the galvanometer, *g*.

Now it will be obvious that when the arm, H, is set upon its arc, G, at the same angle to the line, H′ F′, as the arm F upon the arc, E, then the bridge will balance and the galvanometer will indicate zero ; and hence, inasmuch as the telescope, F, points to the actual object, C, so the arm, H, will point to the corresponding position of the object, C or C′, on the chart, D. Pivoted upon the chart, D, at J′, is an arm, J, which arm may be provided with a telescope or alidade, so that it may be directed upon the object, C, the arm, J, being long enough to make intersection with the arm, I.

If then the arm, J, is trained directly upon the object, inasmuch as the line, H′ J′, joining the pivots of the arms, I J, on the chart, D, corresponds to the base line, F′ J″ extending between the distant stations, and as the angle, C′ H′ J′, equals the angle, C F′ J′, it follows that the intersection of the arms, I and J, at C′ indicates the position of the object, C, upon the chart, D. The chart being drawn to scale and laid off in divisions of know dimensions, it then becomes easy to recognize at a glance both the bearing and distance of the object, C, from any given point on the chart.

In actual practice Lieut. Fiske has adopted the form of apparatus represented in Fig. 2. This consists of a tripod supporting an upper platform which carries the standard upon which is pivoted the telescope. Extending downward through the platform is a shaft which turns with the telescope and standard. An arm is carried by the shaft and moves over a lower table on the upper surface of which is marked the chart. The arm is set parallel to the telescope ; so that when the telescope is directed upon the object, the arm will also be directed upon the object. This parallelism of arm and telescope, however, is not essential. Carried upon the lower table is another arc and a second arm. The intersection of the two arms over the chart, as already explained, shows the position of the distant object ; and the apparatus of Fig. 2, as indicated in Fig. 1, is located at one station, while the arc, E, with its telescope, F, is located at another distant station.

Referring now to Fig. 4, it will be seen that in this case the line, H′ J′, on the chart, D, while corresponding as before to the base line, F′ J, does not coincide with that line, and hence that the arm, J, is itself not directed upon the object. This represents the condition before referred to when the arm, J, is not set parallel to the axis of the telescope, M, but at an angle thereto ; this angle being such that the angle, H′ C′ J′, will continue the same as the angle, F′ C J′, despite a change in relative position of the chart, D ; such as indicated in Fig. 4.

In Fig. 3 is represented a construction of the intersecting arms, I and J, which is especially adapted for the uses before detailed, and which allows of the actual intersecting point being determined with great accuracy. It will be obvious that with a chart laid out on a small scale and using arms, I J, of sufficient width or thickness to give them rigidity, the exact point of intersection of lines drawn through the pivot centers of the arms will be difficult to determine ; and there may be considerable error in regarding the apex of any one of the four angles made by the intersecting arms as the true point indicated. In the device shown in Fig. 3 this source of error is practically eliminated ; and in addition other advantages are secured.

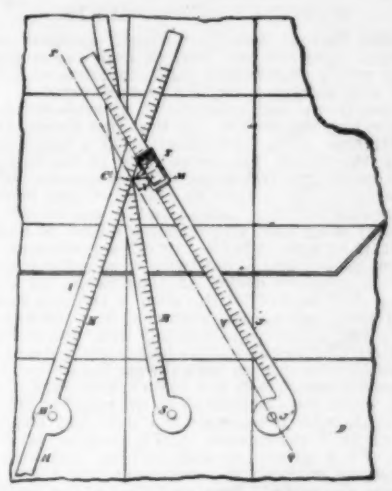


FIG. 3.—INTERSECTING POINTERS, FISKE POSITION FINDER.

The arm, I, has one edge, K, on a line passing through the pivot center, H′. On the arm, J, is a slide, M, which carries a pointer, N, projecting from the edge, V ; the extremity of this pointer being upon an imaginary line drawn through the pivot center, J′, and indicated by the dotted line, P Q. It will be obvious that the point on the arm, I, indicated by the pointer, N, will be the exact point of intersection of lines drawn through the pivot points, H′ J′. The arms, I J′, are graduated lineally to conform to the scale of the chart, D ; so that the distance of the object from both separated stations can at once be read.

Thus, on the rod, I, may be read the distance, H C′, which is that of the object from the station at which is located the telescope, F, Fig. 1 ; and on the rod, J, may be read the distance, J′ C′, which is the distance of the object from the station at which is located the chart, D. If it be desired to determine the distance of the object from any intermediate station between the two mentioned, a third pointer, R, may be placed in position between the two arms, I J, and situated in the same relation thereto as the intermediate station is to the two extreme stations. The distance from the pivot point, S, of this arm to the point, C′, the place of intersection of the edge of the arm with the point of contact of the edge, K, of arm, I, and the apex of the pointer, N, shows the distance of the object from the pivot point, S, and hence from the intermediate station. The slide, M, is moved along by hand. It is provided with an opening, T, through which the scale marks on the arm, J, may be read, and to allow this reading being made, there is a central mark, U, made on the pointer, N, which comes into coincidence with any one of the scale marks.

Telephones are fitted to the telescopes in the same way as in Lieut. Fiske's range finder. This arrangement of telephone and telescope overcomes one great difficulty always found heretofore with observers widely distant from each other ; that is the difficulty of maintaining both lines of sight on the same point.

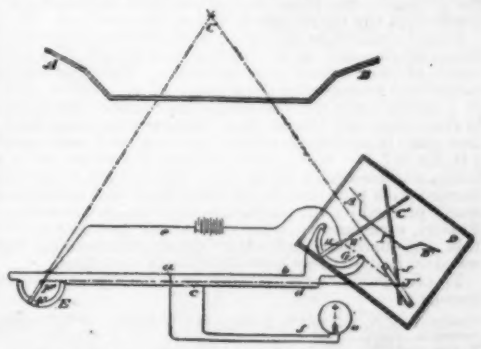


FIG. 4.—DIAGRAM OF FISKE POSITION FINDER.

This difficulty, when the target is partially covered with smoke, as in the case of a war ship firing her guns, has been considered almost insurmountable, since the smoke would cover, at times, the very part of the ship at which the telescopes were directed. The telephones, however, enable two observers to agree instantly upon what point to direct their telescopes, and enable them to change the point as often as the circumstances

of the battle require. The instruments are constructed of aluminum, bronze and iron, and require no care except an occasional cleaning.

Lieut. Fiske's position finder at Fort Hamilton, New York harbor, has now been exposed to the elements for two months without any covering or protection of any kind. At a recent trial, the average error in determining the positions of objects distant between a mile and a quarter and three miles was about one-third of one per cent.—*Electrical Engineer.*

HOWITZER EXPERIMENTS.

MESSRS. KRUPP, Essen, have issued a report on the trials of a heavy howitzer fired at high angles against targets which represented different parts of the armored steel deck of a modern protected cruiser. The experiments are continuations of a series which was begun so long ago as 1879. In that year Krupp fired a 28 centimeter (11·02 inch) howitzer at a target representing the 3-inch protective deck of the then new British battle ship Inflexible. This target was struck by five out of ten rounds at a range of 7,327 yards, or considerably over four miles; and it was shown that at a range of six miles all projectiles might be made to fall within an area of 390 feet by 161 feet—an area, that is, about as long and about twice as broad as that of a first-class cruiser's deck. At that range an armor-piercing steel shell of 562 lb., with a striking velocity of only 442·9 foot-seconds, shattered the plate and remained itself intact; and a chilled iron shell of 506 lb., with a striking velocity of 574 foot-seconds, descending at an angle of 60 degrees with the surface of the target, successfully penetrated the plate. The latest experiments, which were conducted on the range at Meppen, were made with a howitzer of a new and improved type, of 28·55 centimeters (11·27 in.) caliber, and of a length of 11·6 calibers, or 10 ft. 10·7 in. The weight of the weapon without the mounting was 10,998 kilogrammes, or nearly 11 tons, and that of the mounting nearly 14 tons, while the weight of the bed on which the mounting was placed was about 45 tons. The projectiles used were armor-piercing shells of 513 lb., 661 lb., and 986 lb., and steel armor-piercing shells of 661 lb. The charges used were various. Those up to 40·7 lb. in weight were of pebble powder; those above, and including the extreme charge of 57·3 lb., were of the powder known as prismatic *c*/82. The horizontal armor deck target measured 52 ft. by 13 ft., and was composed of four superimposed steel plates riveted together, the three upper layers having, unitedly, a thickness of 76 millimeters (2·99 in.), and the lowest layer a thickness of 13 millimeters (0·51 in.) The total thickness was, therefore, 3½ in. This was backed with iron ribs and wood, and firmly supported at a height of a little over 5 ft. from the ground. All the plates were specially selected, and were of the finest quality. It may be noted that the ordinary thickness of deck armor in cruisers does not exceed 3 in., and that very few vessels of the class possess better protection. The chief exceptions are the cruisers of the Blake type, with a maximum of 6 in., and of the Centaur type, with a maximum of 5 in.; the American ships Philadelphia and Baltimore, with a maximum of 4 in.; the Chinese cruisers Chih-Yuen and Ching-Yuen, with a maximum of 4 in.; and two or three of the latest Spanish vessels. Nearly every other cruiser, and nearly every battleship, has an armored deck thickness of 3 in. or less. The most interesting trials with this armored deck target resulted from the firing of two shots.

The first of these shots was one of a series of ten. The elevation for the series was 45 degrees, the projectile was a steel armor-piercing shell of 661 lb., the charge was 25 lb. of pebble powder, and the range was 3,870 yards, or nearly 2¼ miles. The greatest longitudinal deviation was 95 ft., the greatest lateral deviation was 27 ft. In this series one hit was obtained. There was a longitudinal deviation of 6¼ ft., with a lateral deviation of 19 inches. The striking velocity was 610 foot seconds, and the angle of incidence was 46¼ degrees. The target was pierced, the supports were bent considerably, ten rivets were loosened, the plates were depressed about 1 in. in the center, and the projectile was found unharmed at a depth of 5 ft. in the earth.

The second of the shots was one of a series of sixteen. The elevation for this series was 65 degrees, the projectile was as before, the charge was 33·6 lb. of pebble powder, and the range was again 3,870 yards. The greatest longitudinal deviation was 105 ft., the greatest lateral deviation was 88 ft., and one hit was obtained, the longitudinal deviation of which was 5 ft. and the lateral deviation 20 inches. The striking velocity was 751 foot-seconds, and the angle of incidence about 66 degrees. Once more the target was pierced, the center was depressed nearly 2 in., thirteen rivets were displaced, the supports were seriously bent, and the projectile was found unharmed 15 ft. to the rear of the hole in the target and 4 ft. deep in the earth.

Experiments were also tried against steel targets inclined at an angle of 45 degrees, and placed at a distance of 165 ft. from the howitzer. The horizontal target had represented the summit of the curved deck of a cruiser; the inclined target represented the slopes of that deck, and two of them were experimented with. One was 114 millimeters (4·48 in.) thick, and measured 8 ft. by 6¾ ft.; the other was 89 millimeters (3·5 in.) thick, and measured 6½ ft. each way. Both were well backed with pine and firmly supported, and both were easily pierced by the projectiles from the new howitzer. Finally, experiments were conducted in order to obtain full ballistic and other details concerning the weapon, and to these ends 253 rounds were fired.

The following are particulars of three representative rounds:

Powder	40·7 lb. pebble	40·7 lb. prism	57·3 lb. prism
Projectile	661 lb.	661 lb.	661 lb.
Muzzle velocity	597 f. s.	771 f. s.	1,030 f. s.
Gas pressure per sq. inch	14·9 tons.	9·5 tons.	14·4 tons.

The shots which were fired at the horizontal target were the most interesting. Of the two series of twenty-six in all, twenty projectiles would have fallen upon the target if, instead of measuring what it did, it had been of the shape and superficies of say the Centaur's deck. Of course, the target was fixed, and, of course, in war time men-of-war would generally, if not always, be moving under steam when engaging shore batteries. But, looking to the accuracy of the fire at Meppen, it seems probable that it would not be very difficult for good gunners with a battery of the new howitzers to make occasional hits, even on moving ships, at a range of 2½ miles; and if hits were made, the results to ironclads, as well as to cruisers, would, it may be fairly assumed, be most disastrous. The projectile would pierce a still thicker deck than that of the Blake, and would then retain sufficient velocity to carry itself through the bottom of the ship. And if it were a loaded shell with a bursting charge of from 8 lb. to 20 lb. of powder, the catastrophe would be yet more terrible. Contact with the vessel's upper works might, in the case of a very sensitive shell, cause explosion above the armored deck; but with a percussion fuse of slightly delayed action the explosion might, with considerable certainty, be arranged to take place below the deck and in the midst of the very vitals of the ship. For use, therefore, from fixed positions on shore, especially in connection with such a device as the Watkin position finder, the howitzer seems to have a promising career before it. It will be observed that the experiments contain lessons equally instructive to the naval constructor and gunnery officers.

MACHINE FOR MANUFACTURING PAPER BAGS.

IT was observed that the visitors to the Machinery Palace of the Universal Exposition always stopped in the American section before a machine for automatically manufacturing paper bags, and that their curiosity was thoroughly awakened by the abundance and regularity with which this machine produced bags, dried them, and piled them in groups of fifty. Despite its complication, this machine operated well, and by reason of the deserved success that it met with at the exposition, we believe it of interest to describe and illustrate it. The bags that it manufactures are oblong in form, and will stand upright, thus facilitating filling and making a perfectly regular package. The square bottom may be obtained by the folds indicated in Figs. 1 and 2.

By means of a few slight modifications, there may also be manufactured hexagonal bags such as shown in Fig. 3.

Two views of this machine are shown in Figs. 4 and 5, and the various phases of the manufacture are illustrated in Figs. 6 to 32.

The paper designed to be made into bags is arranged upon a large roller, R (Figs. 4 and 5), and is then seized and carried along with a uniform velocity. It passes in front of a roller (not figured) which deposits upon it a longitudinal layer of paste about four tenths of an inch wide. The paste reservoir is held at a constant level by an ingenious arrangement known under the name of "bird fountain."

The paper thus pasted is then folded upon itself in such a way as to form a long tube, and afterward cut into suitable lengths. The machine next folds the bottom of the bag, and, after definitely forming it, drops it upon an endless band which carries it to a drying cylinder, whence it falls regularly into a three-sided box. From this, the bags, counted out in packages of fifty, are removed by a boy.

All the parts arranged upon the bed of the machine (Fig. 4) are actuated by the shaft, A, through spur gear, bevel gear and cams.

The band of paper slides between a table, a^1 (Fig. 6) and a^2 (Fig. 7), where it receives in succession the folds necessary for the formation of the paper tube. These folds are afterward flattened and compressed by the action of the segments, a^3 (Fig. 8), in such a manner that the bands of paper cover each other and that the previously applied paste unites them.

A sector, *b* (Fig. 8), at this moment makes an aperture in the upper face of the tube to allow the thumb to pass when it is desired to open the bag. In order to prevent the pieces of paper from obstructing the knife, the latter is provided internally with an ejector (Fig. 8 *bis*) consisting of a jointed lever, b^1, carrying at one of its extremities a cylinder that fills the circular cavity of the punch and projects at the other extremity upon the circumference of the sector, *b*. In this position, the cylinder enters the punch a little way, owing to the action of a spring that presses upon the lever, b^1. In consequence of the rotation, the projecting part oscillates on meeting the paper and the cylinder moves toward the exterior, thus driving out the refuse paper (Fig. 8).

After the tube is formed, it leaves the table, *a*, and engages with the plate, *d* (Fig. 9), which takes its place between the lower surface of the paper and the nearest branch of the V formed by each of the lateral folds.

At this moment, a traverse, d^1 (Fig. 9), presses the folds definitely, without, however, flattening the whole surface of the tube. To this effect, the traverse is provided with projections that act on each side of the tube, but leave the middle raised in order to permit of the future introduction of the arm to open the mouth of the bag. It is for the same object that the rollers, *e e* (Fig. 10), placed behind the plate, *d*, are provided with channels. From these, the tube passes between the springs, f^1, fixed upon the support, *f*, which introduce themselves between the folds in order to press the lower fold.

Thus prepared the tube enters the cutting cylinders, *g* (Fig. 11), which also are provided with channels. The upper one carries the knife, which, in its descent, comes into contact with a flexible counter plate in the bottom cylinder.

The tube, cut into sections, reaches the table, *i*, and when the latter has received a sufficient length to form the bottom of a bag, the traverse, *h* (Fig. 12), previously raised, lowers under the action of levers and cams and half opens the mouth of the tube.

Besides, it holds the body of the bag firmly during the folding of the bottom (Figs. 15 to 18).

To the plate, *h*, are jointed arms, *l*, whose triangular extremities (Fig. 13) carry a wire, V, movable around a joint (Fig. 14).

At the moment of the plate's descent, the two levers, *l*, are oblique toward the exterior, but when it advances with the paper tube, these levers approach each other under the action of rods actuated by sliders moving upon oblique guides, and their triangular points introduce themselves between the lateral folds of the half open bag. Then the stops, l^1, cause the wire V of the levers, *l*, to rise vertically (Fig. 14), thus making the paper on the plate, *h*, take the form shown in Fig. 16.

As the forward motion continues, the V of the levers, *l*, is soon turned down completely on the other side of the joint (Fig. 17). At this moment, the bottom is folded in the form of an irregular polygon through the action of the plates, p^1 p^1 (Fig. 18), which, by means of cams, lower and form the final folds of the bottom, while at the same time a rod, *p*, fixed to a curved slide (Figs. 19 and 20) descends between the plates p^1, and advances to the point, n^1, of the bottom folding.

This curved slide is guided in the fixed support, p^2.

Before the folders have begun to act, the forward extremity of the tube has been seized and held by a clamp, *s*, belonging to the drum, S (Fig. 22). The latter, in revolving, unrolls the bag, whose edges are seized besides by two other clamps, t^1 t^1, of the same cylinder, S, which are so spaced that the first, *t t*, determine the folding edge, X X, of the bottom, and the second, t^1 t^1, the other edge, X X^1.

The mechanism of this clamp, *s*, is represented in Fig. 23. It consists of an axis, *r*, the collars of which are received by the ends of the roller, S (Fig. 22). On the exterior of this latter there is a pawl maneuvered by cams, which, through internal springs, r^2, cause the entrance and exit of the cam of the roller, S.

The operation of the clamps, t^1 t^1, is analogous to that of the preceding (Fig. 23 *bis*). A cam causes the revolution of a rod, *k*, carrying two sockets, t^2, into which slide spurs fixed to the clamp, so as to make them grasp and release the paper. When the sockets free the spurs, two springs, r r^1, pull the clamps back to the position shown in the figure.

During the unrolling of the bag, the roller, S^1 (Fig. 24), deposits paste upon the center of the bottom. It is immediately after this operation that the point, *n*, of the fold leaves the roller, S, under the action of a lever carried by S^1, and reaches the following roller, S_2 (Fig. 25), which presses it down upon the bottom of the bag.

As soon as the clamps, *t*, have got beyond the roller, S_2, they recede in such a way as to disengage from the action of the cylinder, S, the finished part that projects freely and deposits itself upon the jointed plate (Figs. 27 and 31). The latter causes the bottom to become upright again (Fig. 28), so that, by the gradual advance of the clamps, t^1, of the cylinder, S, the other portion of the bottom is pressed down upon the preceding (Figs. 29, 30, and 32), by means of the plate V, which rises in order to lend itself to this operation and bears against a counter plate V in order to press the bottom (Fig. 32). The latter, thus finished, is again submitted to a pressure between the plates, *z* and z^1, and its fixation is rendered certain by the action of the drum, S^3, which gives it the final pressure. The clamps, *t*, then re-enter their recess and leave the bag free upon an endless belt that carries it to the drier.—*Revue Industrielle.*

EXPLANATION OF FIGURES.

Figs. 1 to 3—Forms of bags.
Fig. 4—Side view of the machine.
Fig. 5—Plan view.
Figs. 6 and 7—Folding of the tube.
Figs. 8 and 8*bis*—Punching apparatus.
Fig. 9—Folder.
Fig. 10—Feed rollers.
Fig. 11—Cutting cylinders.
Figs. 12 to 16—Opening of the bottom.
Figs. 17 and 18—Folding the bottom.
Figs. 19 and 20—Pressure plate.
Figs. 21 to 26—Rolling up the bag.
Figs. 27 to 30—Folding and pasting.
Figs. 31 and 32—Final pasting.

A NEW MODIFICATION OF THE OPEN HEARTH STEEL PROCESS.

By HERR F. KUPELWIESER.

IN 1888 the author published some calculations showing that in the open hearth process the use of molten iron from the blast furnace would be attended with considerable saving of fuel, especially when the amount of scrap in the charge is much diminished, as in the pig and ore process. The heat of fusion of white pig iron being 260 calories, and the make of steel where ore alone is used, or with a very small amount of scrap, being about equal to that of the pig iron, the heat brought into the bath by the fluid metal would be at least 260,000 calories per ton. If this has to be furnished by the combustion of fuel of a calorific value of 7,000, as the Siemens furnace only utilizes about 25 per cent. of the heat developed, the amount required will be at least 3 cwt., and proportionally more with fuel of lower heating power. Since the above date this method has been adopted and regularly worked at Witkowitz in three furnaces, where, owing to local difficulties in carrying the iron from the blast furnaces, an empty Bessemer converter, previously heated, was used as an intermediate reservoir. Subsequently, the process has been modified by blowing the blast furnace metal in the converter for two minutes, when the bulk of the silicon and manganese is removed, rendering it more suitable for the basic lined furnace. The chemical changes are shown in the following analysis:

	Metal from blast furnace.	Metal blown two minutes.
Silicon	0·95	0·26
Manganese	1·77	0·75
Carbon	3·39	3·03

The amount of heat developed in the blowing is theoretically as follows:

Per ton of 1,000 kilogrammes,			Calories.
From	6·9	kilogrammes of silicon	42,320
"	10·2	" manganese	15,500
"	10	" iron	8,750
			67,110

About one-half of this is, however, lost by radiation, so that the amount added to the metal does not exceed 10 per cent. of that brought from the blast furnace, and as this is subject to further diminution by the losses experienced on the double transfer to and from the converter, the loss and gain of heat probably about balance each other; at any rate the heat added has no particular influence on the working of the open hearth

IMPROVED PAPER BAG MACHINERY.

furnace. The charges at present consist of 90 per cent. cast iron, 10 per cent. scrap, together with the necessary amount of ore for tempering, and some lime for dephosphorizing. The work is done very rapidly, the three furnaces take from fifteen to eighteen charges, or an average of seventeen in twenty-four hours, and the fuel used varies from 10 to 12 per cent. of the weight of the ingots produced—a result which the author considers as unattained by any previous method of working.—*Oesterreichische Zeitschrift fur Berg- und Hutenwesen, in Iron.*

[Continued from SUPPLEMENT, No. 787, page 12574.]

THE ELECTROMAGNET.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

IV.

ELECTROMAGNETIC MECHANISM.

THE task before me to-night comprises the following matters: First, to speak of that particular variety of the electromagnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalizing the pull of electromagnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electromagnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electromagnet.

THE COIL AND PLUNGER.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the *coil and plunger*. Now, from quite early times, from 1822 at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil and plunger was even patented in this country in 1846 under the name of "a new electromagnet." Electromagnetic engines, or motors, were made on this plan by Page, afterward by others, and it became generally known as a distinct device. But even now, if you inquire into the literature of the textbooks to know what are the particular properties of the coil and plunger arrangement, you will find that the books give you next to no information.

They are content to deal with the thing in very general terms by saying: here is a sort of sucking magnet; the core is attracted in. Some books go so far as to tell you that the pull is greatest when the core is about half way in, a statement which is true in one particular case, but false in a great many others. Another book tells you that the pull is greatest at a point one centimeter below the center of the coil, for plungers of all different lengths—which is quite untrue. Another book tells you that a wide coil pulls less powerfully than a narrow one, a statement which is true for some cases and not for others. The books also give you some approximate rules, which, however, are very little to the point. The reason why this ought to receive much more careful consideration is because in this mechanism of coil and plunger we have a real means, not only of equalizing, but also of vastly extending the range of the pull of the electromagnet. Let us take a very simple example for the sake of contrasting the range of action of the ordinary electromagnet with the range of action of the coil and plunger.

Here are some numbers which are given in a paper with which I have long been familiar, a paper read by the late Mr. Robert Hunt in 1856 before the Institution of Civil Engineers, and discussed, with that eminent engineer, Robert Stephenson, in the chair. Mr. Hunt described the various types of motors, and spoke of this question of the range of action.

He recounted some experiments of his own in which the following was the range of action. There was a horse shoe electromagnet which at distance zero—that is when its armature was in contact—pulled with a pull of 220 lb.; when the distance was made only $\frac{1}{1000}$ of an inch (4 mils), the pull fell to 90; and when the distance was increased to 20 mils ($\frac{1}{50}$ of an inch) the pull fell to only 36 lb. The difference from 220 to 36 was within a range of $\frac{1}{50}$ of an inch. He contrasts this with the results given by another mechanism, not quite the simple coil and plunger, but a variety of electromagnet brought out about the year 1845 by a Dane living in Liverpool named Hjorth, wherein a sort of hollow truncated cone of iron (Fig. 57), with coils wound upon it—a hollow electromagnet, in fact—was caused to act on another electromagnet, one being caused to plunge into the other. Now we have no information what the pull was at distance zero with this curious arrangement of Hjorth's, but at a distance of 1 in. the pull (with a very much larger apparatus than Hunt's) was 160 lb., the pull at 3 inches was 88 lb., at 5 inches 72 lb. Here, then, we have a range of action going, not over $\frac{1}{50}$ of an inch, but over 5 inches, and falling, not from 220 to 36, but from 160 to 72, obviously a much more equable kind of range. At the Institution of Civil Engineers on that occasion, a number of the most celebrated men, Joule, Cowper, Sir William Thomson, Mr. Justice Grove, and Prof. Tyndall, discussed these matters—discussed them up and down—from the point of view of range of action and from the point of view of the fact that there was no means of working them at that time except by the consumption of zinc in a primary battery; and they all came to the conclusion that electric motors would never pay.

Robert Stephenson summed up the debate at the end in the following words: "In closing the discussion," he remarked, "there could be no doubt from what had been said that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question commercially speaking. Without, however, considering the subject in that point of view, the mechanical applications seemed to involve almost insuperable difficulties. The power exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. *A powerful magnet might be compared, for the sake of illustration, to a steam engine with an enormous piston but with an exceedingly short stroke; such an arrangement was well known to be very undesirable.*"

Well, from the discussion in 1856—when this question of the length of range was so distinctly set forth—down to the present, there have been a large number of attempts to ascertain exactly how to design a long range electromagnet, and those who have succeeded have, as a general rule, not been the theorists; rather they

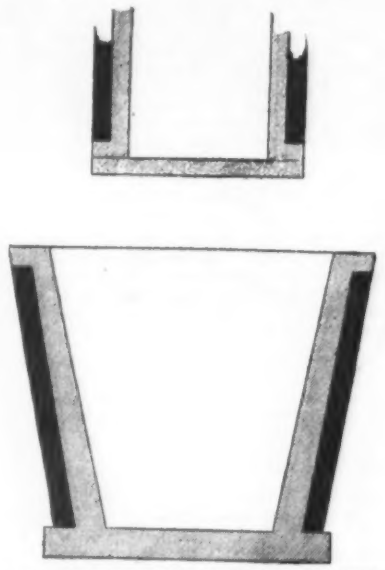


FIG. 57.—HJORTH'S ELECTROMAGNETIC MECHANISM.

have been men compelled by force of circumstances to arrive at their result by some kind. of—shall we call it "designing eye," by having a sort of intuitive perception of what was wanted, and going about it in some rough and ready way of their own. Indeed, I am afraid had they tried to get much light from calculations based on orthodox notions respecting the surface distribution of magnetism, and all that kind of thing, they would not have been much helped. There is our old friend, the law of inverse squares, which would of course turn up the first thing, and they would be told that it would be impossible to have a magnet that pulled equally through any range, because the pull was certain to vary inversely according to the square of the distance. I notice that, in a report of my second lecture in one of the London journals, I am announced to have said that the law of inverse squares did not apply to electric forces. I beg to remark that I have said no such thing. It is well to be precise as to what one does say. There has been a lively discussion going on quite lately whether sound varies as the square of the distance—or rather, whether the intensity of it does—and the people who dispute on both sides of the case do not seem to know what the law of inverse squares means. I have also seen the statement made recently in the columns of *The Times*, by one who is supposed to be an eminent authority on eyesight, that the intensity of the color of a scarlet geranium varies inversely with the square of the distance from which you see it. More utter nonsense was never written. The fact is, the law of inverse squares, which is a perfectly true mathematical law, is true not only for electricity but for light, for sound, and for everything else, provided it is applied to the one case to which a law of inverse squares is applicable. That law is a law expressing the way in which action at a distance falls off when the thing from which the action is proceeding is so small compared with the distance in question that it may be regarded as *a point*. The law of inverse squares is the law universal of action proceeding from a point.

The music of an orchestra at 10 ft. distance is not four times as loud as at 20 ft. distance; for the size of an orchestra cannot be regarded as a mere point in comparison with these distances. If you can conceive of an object giving out a sound, and the object being so small, in relation to the distance at which you are away from it, that it is a point, the law of inverse squares is all right for that, not for the intensity of your hearing, but for the intensity of that to which your sensation is directed. In no case, however, are sensations absolutely proportional to their causes. When the magnetic action proceeds from something so small that it may be regarded as a point compared with the distance, then the law of inverse squares is necessarily and mathematically true.

You may remember that I produced an apparatus (Fig. 27) which I said was the only apparatus hitherto devised which did directly prove experimentally the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

The law of inverse squares is true; but it is not what one works with when one deals with electromagnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetized, so far away from an electromagnet (or rather from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them, that each of them may be regarded by comparison as a point, then the law of inverse squares may be rigidly applied, but not unless.

We want to arrive at a true law. We want to know exactly what the law of action of the coil and plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas. We must begin with a simple case, that of a short coil consisting of but one turn, acting on a single point pole. From this we may proceed to consider the effect on a point pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and last of all from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron, it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 amperes; there are about 700 turns of wire on the coil. The rod is about 1 inch in diameter and 20 inches long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in, and settles down with the ends equally protruding. The tubular coil I have been using is about 14 inches long; but now let us consider a shorter coil. Here is one here only half an inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a maguet that is placed on the axis? First of all, take the case of a very long, permanently magnetized steel magnet, so long, indeed, that any action on the more distant pole is so feeble that it may be disregarded altogether, and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in Fig. 58 represent the center of the

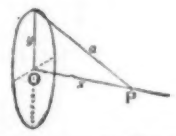


FIG. 58.—ACTION OF SINGLE COIL ON POINT-POLE ON AXIS.

ring, its radius being y. The line O P is the axis of the ring, and the distance from O to P we will call x. The slant distance from P to the ring we call a. Then the pull on the axis toward the center of this coil varies inversely as the cube of a. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to Fig. 59, which represents a sec-

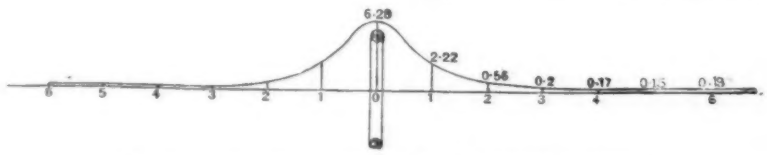


FIG. 59.—ACTION ALONG AXIS OF SINGLE COIL.

tion or edge view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 amperes, circulating once around a ring of 1 centimeter radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central point is 6·28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the radius it has fallen to 2·22 dynes. At a distance equal to twice the radius, or 1 diameter, it is only 0·56 dyne, less than one-tenth what it was at the center. At 2 diameters it has fallen to 0·17 dyne, or less than 3 per cent.; and the force at 3 diameters is only about 2 per cent. of that at the center.

If, then, we could take a *very* long magnet, we may utterly neglect the action on the distant pole. If 1 had a long steel magnet with the south pole 5 or 6 feet away, and the north pole at a point 3 diameters (*i. e.*, 6 centimeters in this case) distant from the mouth of the coil, then the pull of the current in one spiral on the north pole 3 diameters away would be practically negligible; it would be less than 2 per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all of the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as 2 per cent. of the whole amount, we may neglect their action also, for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimeter length of the actual tubular coil which I used in my first experiment, I find there are four. Now if, instead of having four wires distributed over the centimeter, I had one stout wire in the middle of that space to

* Lectures delivered before the Society of Arts, London, 1890. From the Journal of the Society.

carry four times the current, the general effect would be the same. This diagram (Fig. 60) is calculated out on the supposition that the effect will be not greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked A, we take the wires over the first centimeter of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot, we could draw a similar

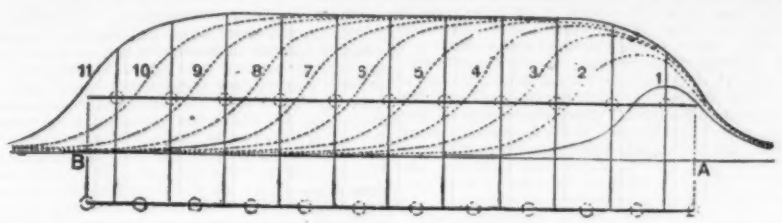


FIG. 60.—ACTION OF TUBULAR COIL.

curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part, add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from A; the curve at that point becomes practically flat, or does not vary more than about 1 per cent. however long the tube may be. For example, in a tubular coil 1 inch in diameter and 20 inches long, there will be a uniform magnetic field for about 15 inches along the middle of the coil. In a tubular coil 3 centimeters in diameter and 40 centimeters long, there will be a uniform magnetic field for about 32 centimeters along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximum amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetizing force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform, is:

$$H = \frac{4}{10}\pi \times \text{the ampere turns per cm. of length.}$$

And, as the total magnetizing power of a tubular coil is proportional, not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetizing effect on a piece of iron that is inserted into the coil may be taken as practically equal

$$\text{to } \frac{4}{10}\pi \times \text{the total number of ampere turns in that}$$

portion of the tubular coil which surrounds the iron. If the iron protrudes as much as 3 diameters at both ends, the total magnetizing force is simply

$$\frac{4}{10}\pi \times \text{the whole number of ampere turns.}$$

Now that case is of course not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetized so as to give us a permanent pole near or at the end of it—quite close up to the end of it when you put it into a magnetizing coil—becomes by that fact further magnetized. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realized. One does not usually work with steel; one works with soft iron plungers which are not magnetized at all when at a distance away, but become magnetized in the act of being placed at the mouth of the coil, and which become more highly magnetized the further they go in. They tend, indeed, to settle down with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetized. Accordingly, we have this fact to deal with, that whatever may be the magnetizing forces all along a tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure. We will construct a curve in which we will plot not simply the magnetizing forces of the spiral at different points, but the product of the magnetizing forces into the magnetism of the core which itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let us still suppose that we are using a very long core, one so long that when the front pole has entered the coil the other end is still a long way off. With an iron core of course it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetizing power. When the core has entered up to a certain point, you have all the magnetizing forces up to that point acting on it; it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing and increasing, although the intensity of the magnetic force from point to point along the axis of the coil remains the same, until within about two diameters from the far end. Although the magnetic force inside the long spiral remains the same, because the magnetism of the core is increasing, the pull goes on increasing and increasing (if the iron does not get saturated) at an almost uniform rate all the way up until the piece of iron has been poked pretty nearly through to the distant end. In Fig. 61, a tubular coil, B A, is represented. Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward B. When it arrives at X, the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along, attaining a maximum, C, about at the further end, A, of the tube. When it approaches to the other end A, it comes to the region where the magnetizing force falls off, but the magnetism is still going on increasing, because something is still being added to the total magnetizing power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, C, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil; from which point there is a very rapid falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three diameters, and gradually vanishing. If, however, the other pole is coming up within measurable distance of B, then the curve will come down more rapidly to a definite point, X_1. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessarily happens. At first the effects are much the same, but as soon as the core has entered about half or a little more than half its length, you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back, and although the magnetizing force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case

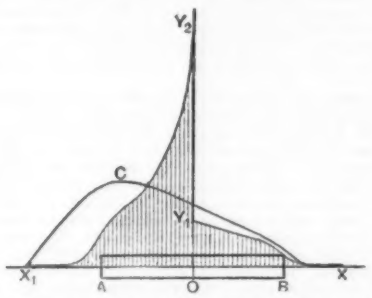


FIG. 61.—DIAGRAM OF FORCE AND WORK OF COIL AND PLUNGER.

the maximum will occur at a point a little further than half way along the coil, and from that point the curve will descend and go to zero at A; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero; there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig. 60, if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it, it is not pulled either way. Now these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about 9 inches long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requires on the average a larger amount of wire, and therefore the same weight of wire will not make the same number of windings.

We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You will find in every case the pull increases and becomes a maximum, then dimishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs just when the lower end gets to the bottom, beyond that the pull is less. Using the same plunger, with these shorter coils, one finds the same thing, in fact more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs, not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using.

If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil. With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil, and when both ends have gone in so far that it gets into the region of equable magnetic field, there is no more pull on one end than on the other; one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry this to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull, but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel x, the element of length must be called dx. Multiply that by f, the force. The force multiplied by the element of length gives us the work, dw, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of f, multiply each by its own short range dx, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:

$$w = \int f\,dx$$

Now what I want you to think about is this: here, say, is a coil, and there is a distant core. Though there is a current in the coil, it is so far away from the core that practically there is no action; bring them nearer and nearer together, presently they begin to act on one another, there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of the core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel, the work done in that travel is readily expressed by the area of the force curve. Think of the curve, X C X, in Fig. 61, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range X X_1.

Now I want you to compare that with the case of an electromagnet where, instead of having this distributed pull, you have a much stronger pull over a much shorter range. I have endeavored to contrast the two in the other curves drawn in Fig. 61. Suppose we have our coil, and suppose the core, instead of being made of one rod such as this, were made in two parts, so that they could be put together with a screw in the middle, or fastened together in any other mechanical way. Now first treat this rod as a single plunger, screw the two parts together, and begin with the operation of allowing it to enter into the coil, the work done will be the area under the curve which we have already considered. Let us divide the iron core into two. First of all put in one end of it. It will be attracted up in a precisely similar fashion, only being a shorter bar, the maximum would be a little displaced. Let it be drawn in up to half way only; we have now a tube half filled with iron, and in doing so we shall have had a certain amount of work done by the apparatus. As the piece of iron is shorter, the force curve, which ascends from X to Y_1, will lie little lower than the curve, X C X_1, but the area under that lower curve, which stops half way, will be the work done by the attraction of this half core. Now go to the other end and put in the other half of the iron. You now have not only the attraction of the tube, but that of the piece which is already in place, acting like an electromagnet. Beginning with a gentle attraction, it soon runs up, and draws the force curve to a tremendously steep peak, becoming a very great force when the distance asunder is very small. We have therefore in this case a totally different curve made up of two parts, a part for the putting in of the first half of the core and a steeper part for the second; but the net result is, we have the same quantity of iron magnetized in exactly the same manner by the same quantity of electric current running round the same amount of copper wire—that is to say, the total amount of work done in these two cases is necessarily equal. Whether you allow the entire plunger to come in by a gentle pull over a long range, or whether you put the core in in two pieces—one part with a gentle pull and the other with a sudden spring up at the end—the total work must be the same; that is to say, the total area under our two new curves must be the same as the area under the old curve. The advantage, then, of this coil and plunger method of employing iron and copper is, not that it gets any more work out of the same expenditure of energy, but that it distributes the pull over a considerable range. It does not, however, equalize it altogether over the range of travel.

A number of experimental researches have been made from time to time to elucidate the working of the coil and plunger. Hankel, in 1850, examined the

relation between the pull in a given portion of the plunger and the exciting power. He found that, so long as the iron core was so thick and the exciting power so small that the magnetization of the iron never approached saturation, the pull was proportional to the square of the current, and was also proportional to the square of the number of turns of wire. Putting these two facts together we get the rule—which is true only for an unsaturated core in a given position—that the pull is proportional to the square of the ampere turns. This might have been expected, for the magnetism of the iron core will, under the assumptions made above, be proportional to the ampere turns, and the intensity of the magnetic field in which it is placed being also proportional to the ampere turns, the pull, which is the product of the magnetism and of the intensity of the field, ought to be proportional to the square of the ampere turns.

Dub, who examined cores of different thicknesses, found the attraction to vary as the square root of the diameter of the core. His own experiments show that this is inexact, and that the force is quite as nearly proportional to the diameter as to its square root. There is again reason for this. The magnetic circuit consists largely of air paths by which the magnetic lines flow from one end to the other. As the main part of the magnetic reluctance of the circuit is that of the air, anything which reduces the air reluctance increases the magnetization, and consequently the pull. Now, in this case, the reluctance of the air paths is mainly governed by the surface exposed by the end portions of the iron core. Increasing these diminishes the reluctance and increases the magnetization by a corresponding amount. Von Waltenhofen, in 1870, compared the attraction exerted by two equal (short) tubular coils on two iron cores, one of which was a solid cylindrical rod, and the other a tube of equal length and weight, and found the tube to be more powerfully attracted. Doubtless the effect of the increased surface in diminishing the reluctance of the magnetic circuit explains the cause of the observation.

Von Feilitzsch compared the action of a tubular coil upon a plunger of soft iron with that exerted by the same coil upon a core of hard magnetized steel of equal dimensions. The plungers (Fig. 62) were each 10·1

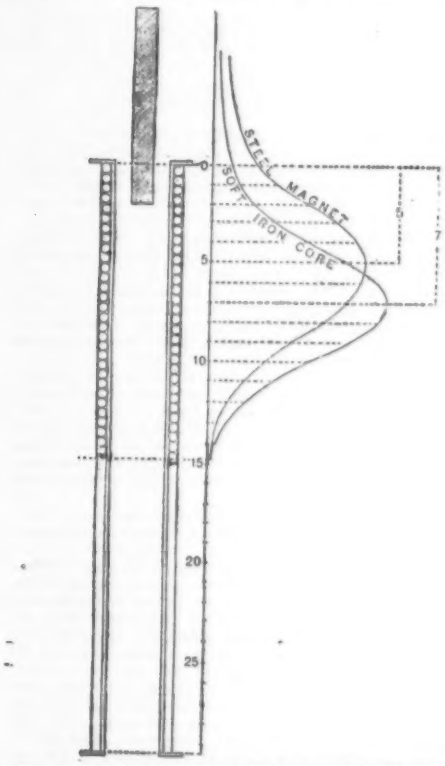


FIG. 62.—VON FEILITZSCH'S EXPERIMENT ON PLUNGERS OF IRON AND STEEL.

centimeters long; the coil being 29·5 centimeters in length, and 4·2 in diameter. The steel magnet showed a maximum attraction when it had plunged to a depth of 5 centimeters, while the iron core had its maximum at a depth of 7 centimeters, doubtless because its own magnetization went on increasing more than did that of the steel core. As the uniform field region began at a depth of about 8 centimeters, and the cores were 10·1 centimeters in length, one would expect the attracting force to come to zero when the cores had plunged into a depth of about 18 centimeters. As a matter of fact, the zero point was reached a little earlier. It will be noticed that the pull at the maximum was a little greater in the case of the iron plunger.

The most careful researches of late years are those made by Dr. Theodore Bruger, in 1886. One of his researches, in which a cylindrical iron plunger was used, is represented by two of the curves in Fig. 63. He used two coils, one 3½ centimeters long, the other 7 centimeters long. These are indicated in the bottom left hand corner. The exciting current was a little over 8 amperes. The cylindrical plunger was 39 centimeters long. The plunger is supposed, in the diagram, to enter on the left, and the number of grammes of pull is plotted out opposite the position of the entering end of the plunger. As the two curves show by their steep peaks, the maximum pull occurs just when the end of the plunger begins to emerge through the coil, and the pull comes down to zero when the ends of the core protrude equally.

In this figure the dotted curves relate to the use of the longer of the two coils. The height of the peak, with the coil of double length, is nearly four times as great, there being double ampere turns of excitation. In some other experiments, which are plotted in Fig. 64, the same core was used with a tubular coil 13 centimeters long. Using currents of various strengths, 1·5 ampere, 3, 4·8, 6, or 8 amperes, the pull is of course different, but, broadly, you get the same effect, that the maximum pull occurs just where the pole begins to come out at the far end of the tubular coil. There are slight differences. With the smallest amount of current the maximum is exactly over the end of the tube, but with currents rather larger, the maximum point comes a little further back. When the core gets well saturated, the force curve does not go on rising so far; it begins to turn over at an early stage, and the maximum place is necessarily displaced a little way back from the end of the tube. That was also observed by Von Waltenhofen when using the steel magnet.

But now if, instead of employing a cylindrical core, you employ one that is pointed, you find this completely alters the position of the maximum pull, for now the point is insufficient to carry the whole of the magnetic lines which are formed in the iron rod. They do not come out at the point, but filter through, so to

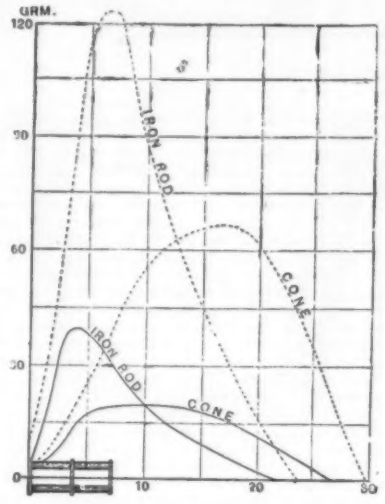


FIG. 63.—BRUGER'S EXPERIMENTS ON COILS AND PLUNGERS.

speak, along the sides of the core. The region where the magnetic lines come up through the iron into the air is no longer a definite "pole" at or near the end of the rod, but is distributed over a considerable surface; consequently when the point begins to poke its nose out, you still have a larger portion of iron up the tube, and the pull, instead of coming to a maximum at that position, is distributed over a wider range. I am now making the experiment roughly with my spring balance and a conical plunger, and I think you will be able to notice a marked difference between this case and that of the cylindrical plunger. The pull increases as the plunger enters, but the maximum is not so well defined with a pointed core as it is with one that is flat ended.

This essential difference between coned plungers and cylindrical ones was discovered by an engineer of the name of Krizik, who applied his discovery in the mechanism of the Pilsen arc lamps. Coned plungers were also examined by Bruger. In Fig. 63 are given the curves that correspond to the use of a coned iron core, as well as those corresponding to the use of the cylindrical iron rod. You will notice that, as compared with the cylindrical plunger, the coned core never gave so big a pull, and the maximum occurred, not as the tip emerged, but when it got a very considerable way out on the other side. So it is with both the shorter and the longer coil.

The dotted curves in Fig. 64 represent the behavior

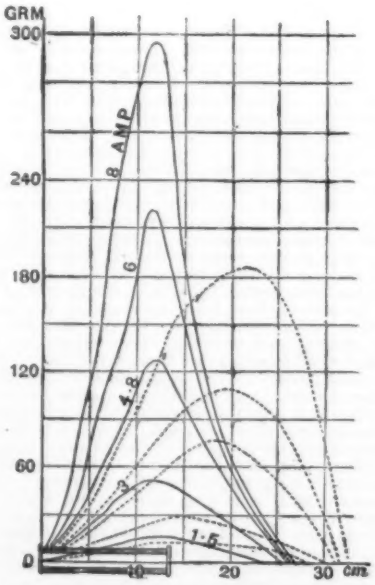


FIG. 64.—BRUGER'S EXPERIMENTS, USING CURRENTS OF VARIOUS STRENGTH.

of a coned plunger. With the longer coil represented, and with various currents, the maximum pull occurred when the tip had come a considerable way out, and the position of the maximum pull, instead of being brought nearer to the entering end with a high magnetizing current, was actually caused to occur further down; the range of action became extended with large currents as compared with small ones. Bruger also investigated the case of cores of very irregular shapes, resembling, for example, the shank of a screw driver, and found a very curious and irregular force curve. There is a good deal more yet to be done, I fancy, in examining this question of distributing the pull on an attracted core by altering the shape of it, but Bruger has shown us the way, and we ought not to find very much difficulty in following him.

OTHER MODES OF EXTENDING RANGE OF ACTION.

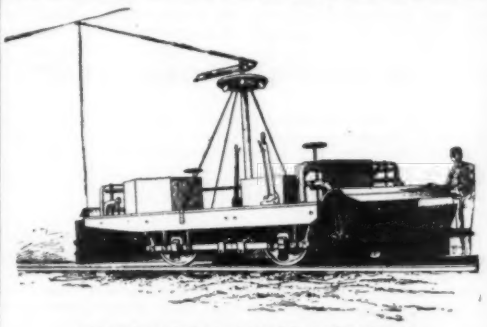
Another way of altering the distribution of the pull is to alter the distribution of the wire on the coil. Instead of having a coned core use a coned coil, the winding being heaped up thicker at one end than at the other. Such a coil, wound in steps of increasing thickness, has been used for some years by Gaiffe, in his arc lamp. It has also been patented in Germany by Leupold. M. Treve has made the suggestion to employ an iron wire coil, so to utilize the magnetism of the iron that is carrying the current. Treve declares that such coils possess, for an equal current, four times the pulling power. I doubt whether that is so; but even if it were, we must remember that to drive any given current through an iron wire, instead of a copper wire of the same bulk, implies that we must force the current through six times the resistance; and, therefore, we shall have to employ six times the horse power to drive the same current through the iron wire coil, so that there is really no gain.

Again, a suggestion has been made to inclose in an iron jacket the coil employed in this way. Ironclad solenoids have been employed from time to time. But they do not increase the range of action. What they do is to tend to prevent the falling off of the internal pull at the region within the mouth of the coil. It equalizes the internal pull at the expense of all external action. An ironclad solenoid has practically no attraction at all on anything outside of it, not even on an iron core placed at a distance of half a diameter of the aperture. It is only when the core is inside the tube that the attraction begins, and the magnetizing power is practically uniform from end to end. Last year I wished to make use of this property for some experiments on the action of magnetism on light, and for that purpose I had built, by Messrs. Paterson & Cooper, this powerful coil, which is provided with a tubular iron jacket outside, and a thick iron disk perforated by a central hole covering each end. The magnetic circuit around the exterior of the coil is practically completed with soft iron. With this coil, one may take it, there is an absolutely uniform magnetic field from one end of the tube to the other, not falling off at the ends as it would do if the magnetic circuit had simply an air return. The whole of the ampere turns of exciting power are employed in magnetizing the central space, in which therefore the actions are very powerful and uniform. The coil and its uses were described in my lecture last year at the Royal Institution on "Optical Torque."

(To be continued.)

AN ELECTRIC SNOW SWEEPER.

IN the accompanying cut is illustrated a track sweeper or cleaner, designed by W. R. McLain, master mechanic of the Des Moines Street Railway Company, Des Moines, Iowa. Its various parts are so arranged



AN ELECTRIC SNOW SWEEPER.

that the running gear and propelling motors may be utilized for the transportation of passengers during the summer season and for a sweeper in the winter. The main object had in view was to overcome the difficulty due to the defective transmission of the motive power whenever the rotary brushes or track sweepers were necessarily raised or lowered in the operation of the machine, and to afford ready and convenient means for accomplishing this part of the operation.

Two 15 h. p. Thomson-Houston motors are mounted upon a truck of ordinary construction in the usual manner, being geared with the axles of the traction wheels and regulated by a rheostat operated from either end of the machine. The platform of the car is rhomboidal in form, so that the two rotary sweepers located at each end of the machine and placed obliquely to the track may be raised to a point even with or slightly above the edge of the platform if desired.

Upon the platform are secured two 15 h. p. Thomson-Houston motors, which operate their respective brushes independently, each being regulated by a separate rheostat. The axial shafts of these motors are geared with their countershafts in the usual manner, the only change in the form of gearing being in the substitution of sprocket wheels, belted with sprocket wheels on the axles of the sweeping brushes, for the toothed pinion wheel ordinarily gearing with the toothed wheels of the car axles.

The sweeping brushes are of steel wire formed in four sections, bound together, the sets of steel wire projecting radially at right angles relative to each other. The device for raising and lowering the sweeping brushes consists of two screw-threaded vertical shafts located on each side of the platform, one of which is provided with a hand wheel, and each having a sprocket wheel, about which a sprocket chain passes, so that both of the shafts may be operated simultaneously from one point.

These horizontal levers being pivoted on a line with

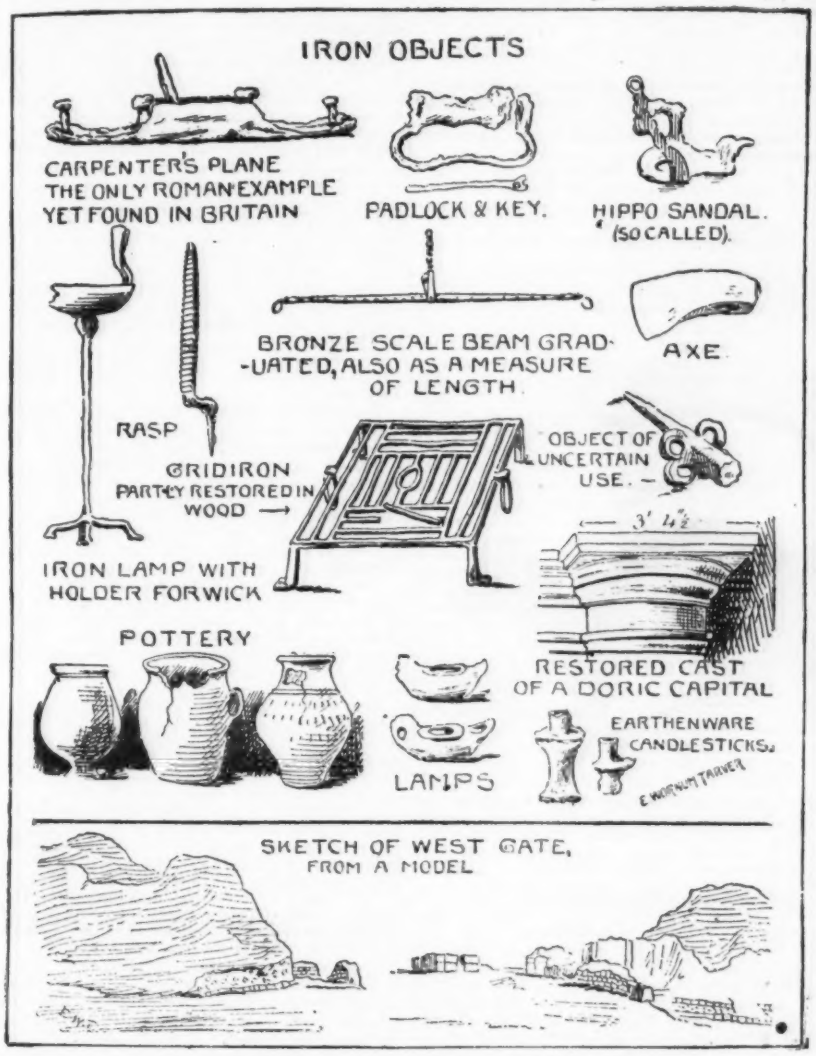
the countershaft carrying the driving sprocket wheels permit the raising and lowering of the sweeping brush without in anywise slackening the sprocket chain about the sprocket wheel on the countershaft and the sprocket wheel of the brush, thus always preserving the transmitting chain taut whatever may be the position of the brush.

From the center of the platform a vertical mast rises to which the trolley pole is pivoted, a cluster of lamps being disposed in a circle at its upper end as shown in the accompanying illustration.

Two horizontal levers are pivoted on a line with the countershaft carrying the driving sprocket wheel, threaded wrought iron blocks being provided, located under each lever, through which the vertical shafts pass. These levers extending forward are bent downwardly over the edge of the platform and constitute the pivots of the brush shaft.—*Elec. World.*

ROMAN REMAINS UNEARTHED AT SILCHESTER.

IN our SCIENTIFIC AMERICAN SUPPLEMENT 784 we gave views of the walls and pavements of the Roman town lately discovered at Silchester, England. The London *Daily Graphic* says: Among the most noteworthy objects now to be seen in the rooms of the Society of Antiquaries at Burlington House, from the recent excavations at Silchester, is a collection of iron tools and



ROMAN REMAINS UNEARTHED AT SILCHESTER.

implements. The gridiron was obviously used over charcoal, and a black earthenware colander suggests a refined knowledge of cookery. The bronze scale beam is in perfect preservation, and was graduated in measure of length. A carpenter's plane, the only Roman example yet found in this country, several ax and mallet heads, a rasp and a file, and some heavy iron spikes of from seven to twelve inches long were also found. One lamp shown is of unusual shape, but there were several found of shapes more generally known. The earthenware candlesticks were also of novel pattern. The pottery is of unusual variety, and comprises Celtic, New Forest, and pseudo-Arretine ware, as well as some highly fired terra-cotta. Much of it was brought to the surface unbroken. Some casts, models, and plans are also included in the exhibition, which will remain open for a fortnight.

ASTRONOMICAL PROBABILITIES FOR THE COMING DECADE.

By CHAS. A. YOUNG, LL D., Professor of Astronomy in Princeton College.

ATTEMPTED prophecy is often damaging both to the prophet and to the cause he has at heart; but it is not easy to see how any harm can be done by trying to point out, in response to the request of the *Independent*, the directions in which the next advances of astronomy are likely to be made, if the reader will only bear in mind that such forecasts are necessarily liable to a large percentage of failure, that in astronomy as elsewhere "the unexpected is sure to happen;" some new and undreamed of discovery absorbs for a time the whole interest of students, so that progress halts just where advance seemed surest, and its direction is completely changed. We dare attempt, therefore, nothing more than a mere indication of what at present seem to be the open roads along which progress seems probable.

First, then, as regards the earth itself. The observations of the last few years have made it certain that the latitude of certain stations in Northern Germany suffers a slight yearly increase and diminution, amounting to about 0·5". Now, this change may be merely apparent, due to changes in the atmospheric refraction such as might conceivably be caused by a seasonable change in the slope of the surfaces of equal temperature in the upper air, or it may be real and physically important, due to an actual shifting of the position of the earth's axis. If the latter supposition is true, the changes of latitude at different stations in widely distant parts of the earth will bear systematic and geometrical relations to each other, depending only upon the positions of the stations; if, on the other hand, the variation is merely apparent, no such relations will hold. It is probable that before 1900 the question will have been settled by combined observations in different countries.

Other problems, relating to the exact form and size of the earth, the law according to which its density increases toward the center, and the rigidity of its mass, are occupying the attention of astronomers, and may, or may not, soon reach solution.

With reference to the moon, the question of its mean temperature, and the variations of its temperature due to the change of phase, is likely to receive fresh light from the experiments of Boys in England, with his new "radio-micrometer," an instrument which, if we may judge from the imperfect accounts at hand, exceeds in delicacy, and far exceeds in manageableness, any of those before employed in such researches.

So great advances have also been made in lunar photography that there seems to be a fair probability that we may soon obtain certain evidence in respect to the question of changes on the moon's surface.

It is more difficult to forecast the probable progress of our knowledge of the sun. During the coming decade there are four available total eclipses—one in South America in 1893, one in Siberia in August, 1896, one in India in January, 1898, and the fourth in the United States in May, 1900.

Just how much information we shall gain from them depends, of course, largely upon the weather at the critical moments, and of late bad fortune has rather predominated on such occasions. Among the most important of the "eclipse problems" now pressing for solution, and likely to be solved if circumstances favor, is that relating to the existence of the so-called "reversing layer," a thin stratum of metallic vapors close to the photosphere or luminous surface of the sun, in which stratum it is supposed that the dark Fraunhofer lines of the solar spectrum have their origin. It is impossible to discuss here the *pros* and *cons* of the question in debate; but a single well directed and unquestionable observation would settle it at once, and we may reasonably hope that such an observation will be obtained before the century closes.

Another eclipse problem relates to the nature and structure of the corona—a problem to be solved, not like the preceding by a single well-directed glance, but to be worked out only by the patient accumulation of photographs and other data, and their careful comparison with theory. It ought to be possible to decide within the next ten years between the principal rival hypotheses thus far proposed, if our eclipse expeditions have any good fortune at all.

The solar prominences also are soon to be investigated by a new method, in which the camera and the spectroscope combine their forces. A young gentleman in Chicago, Mr. Hale, is fitting out a special observatory with a powerful telescope and all the necessary accessories, for the purpose of carrying out a well considered and ingenious plan which certainly offers fair prospects of success.

A line of solar research, in which we have reason to expect substantial progress, is in the more complete identification of the lines of the solar spectrum with those of the chemical elements. A number of physicists, both here and abroad, are engaged in the investigation; Professor Rowland especially is working with apparatus far in advance of anything before used, and has already greatly reduced the number of the lines still unidentified. It is to be hoped, too, one hardly dares to say *expected*, that in the course of the investigations some new light will be shed on the cause of the apparent absence of some of the most abundant and important of the elements.

The heat radiation of the sun is being studied in Sweden by a son of the great Angstrom, by means of new apparatus of extreme ingenuity and delicacy, and with the hope of being able to settle the question whether the amount of heat emitted by the sun does or does not vary considerably from day to day.

Another important subject is the relation between the disturbances on the surface of the sun and their effects upon the earth. Some recent researches by Dr. Veeder, of Lyons, N. Y., consisting in a comparison of the records of the positions of sun spots with the records of auroras and other magnetic disturbances, appear to show that the solar disturbance produces its effect mainly at the moment when it first becomes *visible* from the earth; it is felt when the spot or prominence comes around the eastern edge of the sun's disk. This indicates a purely "radiant" action, like that of light or of electric induction; and it is likely that further study will bring out more definite information.

Passing to the planetary system, it may be expected that Schiaparelli's discovery of the moon-like rotation of Mercury will soon be fully confirmed, and that we shall know certainly whether, as now seems likely, the earth's twin sister, Venus, also behaves in the same very unearthlike and objectionable manner—objectionable, that is, from the point of view of a would-be inhabitant. As for Mars, and the questions relating to the reported wonders of that planet's surface, we may, perhaps, hope that the coming close opposition of 1892 will throw new light upon the subject. But over-confidence in this respect would not be wise; for the phenomena discussed are so delicate, and apparently visible by so few of the observers, that their verification and explanation will hardly be reached with ease.

Jupiter and his "red spot," with the various markings of his surface, will be studied assiduously; and we may possibly arrive at some new and sure conclusions as to their nature and the cause of their hitherto unexplained behavior.

The recent remarkable success of the youngest Struve in his investigations of the inner satellites of Saturn warrant the expectation that it will be followed up, and will result in a better understanding of that wonderful and beautiful system of rings and moons. Uranus may, perhaps, within the decade, yield the secret of his daily rotation, and something more may possibly be made out of his spectrum. As for Neptune, there seems little likelihood that, for the present at least, we shall be able to learn much more about it.

In the subject of meteoric and cometary astronomy, it is especially difficult to tell "what a day may bring forth." A great comet may appear any time, and present a series of phenomena that will at once settle all the debated questions of cometary constitutions; or we may have to wait for years for an opportunity to test the various conflicting theories. But the ability we now possess, through the power of the Lick telescope and other great instruments, of following these bodies far beyond any limits formerly possible, will probably give so much greater accuracy to our determinations of cometary orbits that we shall be able to reach something like certainty as to the real relation between the comets of short period and the planets which seem to be responsible for their connection with the solar system. In tracing the motions of the so-called Lexell-Brooks comet, for instance (1889, V), the observations which the Californian observers have just secured at a distance of more than 300,000,000 miles from the sun will aid very greatly in determining the precise circumstances of its encounter with Jupiter, in 1886, and will go far to settle the still doubtful question whether it is really the old comet of 1770 returned from its wanderings, or only another member of the same cometary "group."

We may note that meteoric showers are due in 1898 and in 1900, the former about November 28, from the swarm that accompanies the lost comet of Biela; the latter, the well known Leonids, about November 12.

As to stellar astronomy, everything looks favorable for rapid progress. Before the century ends the great catalogue of the *Astronomische Gesellschaft* will be finished and published, and the chart of the photographic campaign will probably be nearly if not quite completed. The spectroscopic survey of the heavens, undertaken as part of the Draper memorial work will also be nearly finished, and the spectroscopic observations of individual stars will probably have given us the motions in the line of sight of a large number of them, and will very likely have brought to light numerous "spectroscopic binaries," like Mizar and Spica. It is probable, also, that the studies of variable stars will have resulted in a considerable increase of our knowledge of their behavior and its causes; at the same time, it will not be strange if we find progress rather difficult in this direction.

It is almost certain that photographic and other processes will soon give us the parallax and distance of a greatly increased number of stars—enough, perhaps, to justify some more definite conclusions than are now

possible as to the dimensions and constitution of the sidereal universe.

As regards the nebulæ, it is already clear that photography is to add immensely to our knowledge of their structure and extent, as well as of their relation to the neighboring stars. It is quite possible also that our plates may even enable us to obtain the parallax of a few of those which are well defined in outline. The spectroscope, on the other hand, has already proved its ability to measure their motions toward or from us, and it may perhaps before long succeed in disclosing to us the still unknown element which, with hydrogen, seems to compose most of their substance.

The next ten years are sure to bring a great change in the methods of observation, perhaps sufficient to transform the whole aspect of practical astronomy. It is clear that photography is more and more to supersede the eye in observation, and that in the dimensions and accuracy of astronomical instruments there is like to be fully as great an advance as in the preceding decade. If the new Jena glass proves to be all that is represented in some quarters, its use will greatly improve our telescopes.

In theoretical astronomy, also, there is good reason to expect important progress by the application of the new mathematical ideas and methods to the problems of planetary and stellar motion: it already begins to look as if before very long the hitherto unmanageable "problem of three bodies" would yield to the new analysis, and receive a solution as complete as that which Newton found for the simpler one where only two are concerned. Still this is far enough from certain.—*The Independent.*

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT NEW YORK CITY DURING THE YEAR 1890

AIR PRESSURE, IN INCHES.

Mean, reduced to 32° F	29·86
Mean, reduced to 32° F. and sea level	30·06
Highest, reduced to 32° F. and sea level, January 1	30 77
Lowest, reduced to 32° F. and sea level, October 29	29·35
Annual range	1·42
Mean monthly range	0·87

MEAN HOURLY VALUES.

1 a. m	30·06	1 p. m.	30 04
2 "	30 05	2 "	30 03
3 "	30·05	3 "	30·02
4 "	30·05	4 "	30·02
5 "	30·06	5 "	30·03
6 "	30·06	6 "	30·03
7 "	30·07	7 "	30·04
8 "	30·07	8 "	30·04
9 "	30 07	9 "	30·06
10 "	30·07	10 "	30·06
11 "	30·07	11 "	30·06
12 noon	30·05	12 m'd't	30·06

AIR TEMPERATURES, F. DEGREES.

Mean	54
Highest, July 8	95
Lowest, March 7	6
Annual range	89
Greatest daily range, February 7	40
Least daily range, September 14, August 9	4
Greatest monthly range, March	65
Least monthly range, June	34
Mean of absolute monthly range	45
Mean daily range	15

MEAN HOURLY VALUES.

1 a. m	50	1 p. m	56
2 "	50	2 "	57
3 "	50	3 "	57
4 "	49	4 "	57
5 "	49	5 "	56
6 "	49	6 "	56
7 "	49	7 "	55
8 "	50	8 "	54
9 "	51	9 "	53
10 "	52	10 "	52
11 "	54	11 "	52
12 noon	55	12 m'd't	51

Number of days maximum below 32°: January, 2 days; February, 1 day; March, 4 days; November, 1 day; December, 7 days. Total, 15 days.

Number of days minimum below 32°: January, 15 days; February, 11 days; March, 15 days; April, 3 days; November, 4 days; December, 23 days. Total, 71 days.

Number of days maximum above 90°: July, 4 days.

First ice formed, November 21; last ice formed, April 1.

HUMIDITY.

Mean dew point, degree	43
Mean relative humidity, percentum	73

CLOUDINESS.

Mean (scale 0 to 10 tenths)	5·4
Greatest mean monthly, February and March	6·8
Least mean monthly, June	5·1

There were 83 cloudless days, 150 partly cloudy days, and 133 cloudy days.

WIND.

Prevailing direction	Northwest
Total movement, miles	98,784
Greatest monthly movement, miles, December	11,231
Least monthly movement, miles, September	6,534

Highest velocity from northwest, 55 miles per hour, January 22. Number of times blowing from the north (two observations daily), 81; northeast, 72; east, 22; southeast, 90; south, 114; southwest, 106; west, 91; northwest, 154; calm, 0.

MEAN HOURLY VALUES, MILES.

1 a. m	11	1 p. m	13
2 "	10	2 "	13
3 "	10	3 "	13
4 "	10	4 "	13
5 "	10	5 "	12
6 "	10	6 "	12
7 "	10	7 "	12
8 "	10	8 "	11
9 "	11	9 "	11
10 "	12	10 "	11
11 "	12	11 "	10
12 noon	13	12 m'd't	11

PRECIPITATION.

(*From rain, snow, hail and sleet.*)

Total inches, 52·30. Total depth of snow fall, 45·6 inches, distributed as follows: January, trace; February, 4·0 in.; March, 21·3 in.; April, 1·2 in.; November, trace; December, 19·1 in.

The last snow of season occurred on April 1. The first snow of season occurred on November 27. Greatest monthly precipitation in September, 8·21 in. Least monthly precipitation in November, 0·82 in. Greatest daily precipitation in any consecutive 24 hours, September 16 and 17, 5·12 in.

The average annual precipitation at New York City (for the past 20 years), in inches, is 43 54.

For each month: January, 3·76; February, 3 69; March, 3·88; April, 3·27; May, 3·05; June, 3·26; July, 4·36; August, 4·84; September, 3·34; October, 3·36; November, 3·53; December, 3·21.

There were 144 days on which 0·01 in., or more, of rain or melted snow occurred.

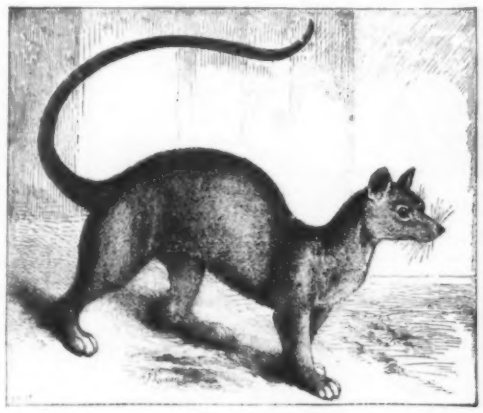
Thunder storms occurred as follows: In March, 1; April, 3; May, 5; June, 9; July, 3; August, 9; September, 5; October, 1.

The last frost of season occurred on April 1; the first frost occurred on October 9.

L. N. JESUNOFSKY,
Sergeant Signal Corps.

THE FOUSSA, A STRANGE ANIMAL.

A RECENT addition to the zoological society's collection of live specimens is quite unique, not only in European shows of natural history, but in animal nature;



THE FOUSSA (CRYPTOPROCTA FEROX) AT THE ZOOLOGICAL SOCIETY'S GARDENS.

for it represents to science the sole type of its genus and of the oddly named "Cryptoprocta" family of flesh-eating mammals. It comes from Madagascar, its only known habitation on the globe, where it is called the "fousa," the "forassa," the "pintsala" or "kintsala," and has been described by travelers. This beast is about 3 ft. long, somewhat resembling the genet or civet cat, but its shape is rather like that of a weasel. With sharp retractile claws and strong teeth, it is a formidable beast of prey, and often kills wild hogs, goats, or even small cattle, springing fiercely at the throat. Its habits are nocturnal, and it perpetrates much havoc in the western parts of the large island of Madagascar.—*Ill. London News.*

CORAL GROWTHS ON SUBMARINE CABLES.

SUBMARINE cables have before now rendered unexpected services to science, and the following is one of the latest: Very little, it seems, is as yet known as to the rate of growth of corals, but some very interesting details have been published by M. Alexander Agassiz in the August number of the *Bulletin of the Museum of Comparative Zoology at Harvard College*, with regard to a series of specimens which were taken in June, 1888, off the Havana and Key West cable, from a portion repaired in the summer of 1881, so that the growths could not be more than about seven years. It must be noted that this portion of the cable was laid at a depth of only from six to seven fathoms, and that the district in which it was laid was most favorably situated as regards food supply to the corals. Some of the specimens belong to species whose rates of growth have not yet been recorded. Verrill mentions that the thickness of the *Orbicella annularis* coral formed in 64 years was not more than about 8 in.; the specimens from the Havana cable grew to a thickness of 2½ in. in about seven years. *Manicina areolata* has grown to a thickness of 1 in.; while *Isophylla dipsacea* shows a still more rapid growth, projecting 2½ in. above the cable. Of course it is quite possible that these corals are of less than seven years' growth, but it is not probable that more than a short time passed before some of the swarms of pelagic coral embryos which must have floated past the cable found a place of attachment thereon.

THE PHYLLOXERA AND AMERICAN RESISTANT STOCKS.

By Professor C. V. RILEY.

THE continued spread of the grapevine phylloxera is sufficient to account for the sustained interest which grape-growing countries feel in the subject of resistant American vines. The insect has at last invaded the department of Marne, in which the best champagnes are made, and the most rigorous measures are being taken by the French authorities to mitigate the evil. It is also reported in the chief Rhine vineyards, where consternation prevails as a consequence. Its recent advent in New Zealand has induced most stringent laws looking to suppression or diminution of the evil; and, with the experience of the older countries to guide them, it is not surprising that they should be deeply interested in the question of our American resistant stocks.

I have lately been called upon to answer some leading questions on the subject from one of my valued correspondents, Mr. R. Allen Wight, of Auckland, who has been delegated by the government to investigate phylloxera matters at Whangarei. Many persons in the United States, and particularly in California, are seeking the same information, and I would give publicity through the columns of the SCIENTIFIC AMERICAN to the following portions of my reply to Mr. Wight.

It must be remembered that the resistance of American vines is to the root-inhabiting form of the phylloxera only. The leaf gall form occurs at times abundantly on many American species and varieties, especially those with smooth and thin leaves. Thus, it is very common on the wild varieties of *Vitis riparia*, and the cultivated sorts derived from that species, Clinton, Solonis, Taylor, etc., all of which have proved to be of great value as resistant stocks in the experience of French vineyardists. The gall form is, in other words, as you have doubtless gathered from my writings, but a transient and comparatively harmless form of the species. With European vines, which are altogether derived from the single species, *V. vinifera*, the leaf galls rarely occur, and are rudimentary, and contain fewer eggs than with American vines. The susceptibility of these sorts to the attacks of the root form is too well known to need further iteration.

Before taking up your direct inquiry as to the merits of the Isabella as a resistant stock, it may be well to briefly go into the general subject of resistant American stocks.

The American species of *Vitis* of importance to the grape grower are: *V. æstivalis*, *V. riparia*, and *V. labrusca*.

The different varieties derived from the *æstivalis* are commonly employed in France for direct production on account of the superior quality of their fruits. They are propagated with comparative ease from cuttings, and some of them are also widely used for stocks on which to graft European vines, but are somewhat inferior to other varieties for this purpose. The American varieties ordinarily grown and most highly prized in France for their own fruit are the Jacquez, Herbemont, Black July, and Cunningham.

The varieties of *Vitis riparia*, both wild and cultivated, are used almost exclusively as resistant stocks in France, for which purpose they easily take first rank. They are remarkably suited to this role, not only by reason of their immunity from the phylloxera, but by the ease with which they may be grown from cuttings, and afterward grafted.

The following varieties have shown themselves to be especially adapted to this purpose: (1) the wild varieties generally, which for a number of years have been exported from our central States, in large quantities, into France; and (2) the cultivated varieties, particularly the Solonis, Clinton, and Taylor.

In reference to your questioning my assertion of the phylloxera-proof character of the Clinton, it will only be necessary to call your attention to the fact that the Clinton was the first variety noted in France to resist the phylloxera, and has, of all American vines, been most widely cultivated. It is also extensively used for stocks, but requires special conditions of soil and climate to insure favorable results. I have seen most admirable results on this variety in the vineyards of the Duchess Fitzjames, at Pageset. The Taylor is quite similar in these respects to the Clinton. The Solonis, which is either a wild race of Riparia or a hybrid of that species, is absolutely valueless for its grapes, but excels the others in its resistance to the phylloxera, and will thrive in very moist soils under conditions where other varieties of Riparia fail. In fact, the ordinary wild Riparia is more used than any other for resistant stocks, and I noticed in my last summer's journeyings that it had given rise to some variations, some of which were better than others.

The varieties of *V. labrusca*, while resisting the phylloxera better than the vines of Europe, are inferior in this respect to other American vines. Certain varieties, as for instance the Concord, can be grown successfully in France, but others (the Isabella and Catawba, for example) succumb to the root louse. They are employed in France chiefly as resistant stocks, and for this purpose the Concord is almost the only variety used. They are inferior to the Riparia varieties for this purpose, and can only be recommended where better sorts are not available. You will see from this that the Isabella, of which you inquired particularly, is of but secondary value in its power of resisting the phylloxera; and, in fact, in the newer plantations in France this variety is no longer employed.

There are many valuable hybrids of the American species of Vitis, both for direct culture and for use as stocks. The important ones employed as stocks are the Elvira, Noah, Triumph, York, Madeira, Vialla, etc., of which the Vialla, perhaps, of all the stocks employed in France, gives the greatest percentage of successful grafts, and affords the best results in grafting on cuttings. The experience of the French viticulturists has shown that the utmost importance attaches to the adaptation of the soil to the various American vines. Sorts which are entirely resistant in certain soils are valueless for this purpose in others, and it becomes necessary to know the particular soil best adapted to each of the different varieties of grape.

I quote the following passage from a report which I have recently submitted on class 75, viticulture, at the Paris Exposition:

"*L'Ecole de Montpellier* has formulated the statement quoted below, which will be of interest as giving the various classes of soils, together with the American vines best adapted to each.

"1. New, deep, fertile soils *Riparia tomentous* and *glabrous, Jacquez, Solonis, Vialla, Taylor*, and *Cunningham*.

"2. Deep soils somewhat strong, not wet: *Jacquez, Riparia, Solonis, Cunningham, Vialla, Taylor*.

"3. Deep soils of medium consistency, new and not dry in summer: *Riparia, Jacquez, Solonis, Vialla, Taylor, Black July*.

"4. Light, pebbly soils, deep, well drained, and not too dry in summer: *Jacquez, Riparia* (wild), *Taylor, Rupestris*.

"5. Calcareous soils, with subsoil shallow or granitic: *Solonis, Rupestris*.

"6. Argillaceous soils, white or gray: *Cunningham*.

"7. Argillaceous soils, deep and very wet: *V. cinerea*.

"8. Deep, sandy, fertile soils: *Riparia* (wild), *Solonis, Jacquez, Cunningham, Black July, Rupestris*.

"9. Light, pebbly soils, dry and barren: *Rupestris, York, Madeira, Riparia* (wild).

"10. Deep soils with a tufa base and salt lands: *Solonis*.

"11. Soils formed of *debris* of tufa, but sufficiently deep: *Taylor*.

"12. Ferruginous soils, containing red pebbles of silica, deep and somewhat strong, well drained, but fresh in summer: All the varieties indicated, and in addition *Herbemont, Clinton, Cynthiana, Marion, Concord, Herman*."

The value and popularity of the American stocks is shown in a recently published report of the Superior Phylloxera Commission, and a table giving the number of acres renewed by means of their use for a number of years, taken from this report, is given in *Insect Life*, vol. ii., p. 310.

THE AGE OF TREES FOR TRANSPLANTING.

WHERE large trees or shrubs are transplanted, it is generally either with the object of giving them a better position or of producing an effect at once. When the object is to furnish the landscape around a mansion, perhaps newly erected, it is a good plan to plant at least a portion of the ground with trees of as large a size as can be procured and transplanted safely; but otherwise, except in isolated and exceptional cases, it is better to begin with young trees. It is a well known fact that trees raised from seed where they are to grow make the tallest and finest specimens; but, for several reasons, this plan is not generally practicable now in this country, and small plants from the nursery are generally employed. It often becomes necessary, however, to thin out shrubberies and plantations in parks and on estates, and the thinnings present a ready means of extending these in other directions; and if transplanted carefully they grow and do well. It would be difficult to say at what age such subjects as chestnuts, beeches, oaks, elms, planes, thorns, spruces, and firs, etc., may not be moved with success up to thirty years of age, so much depends upon circumstances; but it is seldom wise to leave trees intended to be transplanted until they reach that age, because they get drawn up weakly by being so long crowded. The larger the trees, the greater the difficulty, no matter what their age may be. In warm situations and in good deep soils, the tops soon grow large and the roots extend, and hence both are most difficult to carry away. With proper transplanting machines, and care, of course, almost any tree may be transplanted; but transplanting operations on a large scale are too often carried on with rough-and-ready appliances. I have seen many hundreds of trees moved, and very few of them failed altogether, though none was under fifteen years of age, and many would be more; but in all cases the common spruce suffered worst, while Pinus austriaca and the Scotch fir seemed to endure considerable hardships and yet thrive. Both I have seen moved during severe frosts at midwinter and grow, but not all. In mild weather both may be moved at any time, provided a good ball of soil is attached to the roots.

Deciduous trees will transplant successfully as long as they are growing vigorously, and while they are not too heavy and tall to carry from one place to another, provided they are moved at the proper time and with as many roots as possible; with them a ball of soil is not of so much consequence. However, moderate sized trees are the best, as they need less staying, and are not so liable to be prostrated or shaken by wind. I once lifted fifty vigorous apple trees, none of them less than forty years of age probably. They had not been disturbed at the root for many years; consequently the roots were all strong and fiberless, and had no soil to them. The result was that none of the trees put forth a leaf the following season, and made a very feeble growth the second year, but they eventually recovered and did well.

As regards evergreen trees and shrubs like the holly, yew, laurel, etc., it is different. I have transplanted these of all ages up to about forty years on many occasions during the past eighteen years, the object of moving large specimens being to fill up gaps; but if I had to do the same work over again, I would prefer young trees from five to ten years of age. Very few hollies died outright, thanks principally to the fact of their being moved at the right season—May or August; but numbers of them received such a severe shock in moving, that they have hardly added a foot to their stature in ten years or more. When a holly tree dies from transplanting, its leaves soon wither, but hang on the tree; when it lives, it probably casts more or less of its leaves, and not unfrequently the whole of them, leaving the branches quite naked, but not dead, except, perhaps, at the extremities. Still, in such cases it is years before the tree is fairly clothed with fresh foliage, while no growth is made, and in the end it is often necessary to cut all the branches back considerably in order to induce a fresh and stronger break from the old wood, thus greatly reducing the size of the tree, which is overtaken and surpassed by younger and smaller trees put in at the same time. Undoubtedly the best way to have a good holly fence, be it high or low, is to begin with young trees in good health. It is the same with yews and laurels, especially the latter, which, if moved when several years old, soon age or grow feeble at the top. When the branches are well cut back at the same time, however, laurels grow well enough, if in good health to begin with; but cutting the branches defeats the object of the planter of large bushes. Pruning of evergreens recently transplanted should always be deferred till April, or even later. So long as growth has not commenced, nothing is lost; something is rather gained, for wounds soonest heal over when growth follows soon after pruning. Many a large evergreen is killed or injured by being cut too severely back. Deciduous trees may be moved at any season between leaf-falling and bud-bursting in spring, but October and November are the best months, and from February till April or May the next best. I have moved elms, planes, and horse chestnuts, etc., on an emergency after they had come well into leaf and without injury, taking care to water well for some time after planting. Deciduous trees, planted at the right time, do not need much watering. Evergreens should be planted at the same season as the deciduous trees, with the exception of hollies and some of the more delicate fir tribe, both of which should be transplanted in August or September, or late in spring, at least in the case of large trees.

At whatever age or season trees are transplanted, success depends largely upon the manner in which the operation of raising the roots of the trees is performed. Some people think if they get a good ball of soil away with the root, it is enough; but it all depends where the roots are. Trees that produce a bunch of roots like a box tree will move with a small ball, because all the roots are near to the stem, but in the great majority of trees the roots spread out a considerable distance and all the fibrous or feeding roots are mostly at the extremity.—*X, The Garden*.

REMARKABLE CASE OF SKIN GRAFTING.

IN Chicago, Jan 18, 132 Knights Templar submitted themselves to the surgeon's knife to allow a small piece of flesh to be taken from each, that the skin so taken might be engrafted upon a brother member, Mr. John O. Dickerson, upon whom an operation had been performed for cancer. The cancerous affection had been removed from the patient's right hip, and had left an ugly surface that must become a running sore if this aid was not afforded. Dr. Christopher Fenger performed the operation. In the little operating room the doctor stood over the table upon which lay the patient knight, upon his side, his face resting upon one arm. He was clothed as he had been removed from his bed. The raw flesh that lay over the muscles had been exposed by the surgeon's knife which had removed the cancerous growth. The edges of this mass, oval in shape and covering 144 square inches of surface, were marked by an irregular ridge of half-healed, hardened flesh. Dr. Mertz administered chloroform, when Dr. Fenger used a connette upon the surface, which scraped any hardened accumulations away and made it so raw that the flesh which should touch it would graft properly. When this was done the wound was covered temporarily with oiled silk and antiseptic gauze. The patient was then allowed to recover his faculties.

When Dr. Fenger announced that he was ready for the first victim, there were grouped around the table fifteen medical students. Dr. Bernauer stood ready to receive the first flesh offering. Assisting in the operation were Drs. R. L. Leonard, T. D. Palmer, and C. S. Taylor, of the commandery staff, and Drs. C. O. Strickland, G. J. Tobias, W. M. Ballard, C. B. Plattenberg, and L. Mertz. Sir Knight Henry Turner, past grand commander, headed the first five knights who presented themselves. The process of taking the skin was the same for all. The knight was disrobed so that the left arm and shoulder were bared. Having taken the precautions suggested in the physicians' circular, the knight was also asked regarding tendencies toward any skin disease and his pulse tested. Those being satisfactory, the arm was vigorously washed with soap and water. Dr. Strickland then shaved the member about the deltoid or muscular portion of the arm, which was again washed, so that every bit of cuticle and foreign substance was removed. In the second washing the arm was rubbed so vigorously with a hair cloth that the surface became highly reddened and myriads of minute beads of blood oozed out of the open pores.

A solution of alcohol and carbolic acid was applied to the surface and the knight conducted to the room where the patient lay. A sheet was wound over his shoulder and so that his view of the place of cutting was shielded. Each knight was provided with his own razor, which Dr. Bernauer took as he entered. The doctor raised the victim's elbow in his left hand to a position horizontal with the shoulder, and with the razor made a cut with the instrument of from half an inch long in some to two inches in others. The width of about half an inch could not be accurately discerned, for as soon as cut it would shrink and curl up. As soon as the section or cut was made, Dr. Mertz dusted on iodoform and applied a cotton bandage which was wound half round, and the roll given to the patient, who was returned to a room across the corridor. There the bandage was fastened, and "tonic" given to the hero. The skin was cut so as to involve only the live skin below the cuticle, and did not touch the tissues beneath.

After the piece of skin was cut, Dr Bernauer carried the skin, tinged slightly with blood upon its under surface, on the razor to the diseased part. Dr. Fenger seized it with tissue forceps and adjusted it delicately to the wound, from which the temporary bandage had been removed. As the patient lay upon his side, the first pieces were placed near the groin and successively followed until the surface was entirely covered. These pieces was joined as closely together as possible, the interstices being filled afterward. The operations were continued until the requisite pieces of skin were obtained. When the surface had been completely covered it presented a curious sight, resembling a crazy quilt. The action of the air and the inherent qualities of the different pieces of skin caused the patched surface to assume varied colors of brown, blue, and red. A few pieces of skin preserved their pink, though faded, tint. Many pieces were shaded deeper upon the edges than in the center, but each piece preserved its individual color. Streaking evidences of blood appeared in the interstices, and several spots tinted the surface with its brightest color. Over this unique but revolting surface was dusted boracic acid powder. It was covered with oiled silk and cotton, the patient's waist and hip being bound with an "eight" bandage.

From some of the knights two pieces of flesh were taken. The fat men fared worse than the lean ones. There was also discrimination in the size of the pieces, resulting mostly from the nature of the spot to be covered. From burly Tom Currier three pieces of robust skin were taken. Some of the knights struggled hard to nerve themselves for the ordeal. Occasionally a victim trembled as he removed his clothing, and the peculiar smell of the operating room strongly affected many of those who entered. Two of the knights fainted and were relieved from undergoing the ordeal. But most of the men tried to be jolly, and largely succeeded. The patient smiled as his brothers entered, and greeted all of them by some word or name.

The wounded men were warned against removing the bandage for ten days, when they were assured the wound would heal.

The knights had been prepared for the ordeal by the following circular letter signed by the surgeons:

"1. You are selected by us as a suitable candidate for the operation.

"2. If you have a razor, please see that it is put in perfect order, duly honed and stropped ready for use; attach a small tag or write your name on handle and bring it with you. It will be used upon yourself first, and afterward upon such as have no razor of their own until the edge has lost its sharpness, when it will be returned to you.

"3. Please take your weekly tub or sponge bath Saturday night or early Sunday morning, and put on clean, well aired underclothing.

"4. Avoid undue exercise and abstain from the use of alcoholic stimulants, including beer, for at least twenty-four hours preceding the operation.

"5. Retire sufficiently early Saturday night to assure a good night's rest, and eat a moderate breakfast Sunday.

"6. Do not worry about the operation, as it is similar to being vaccinated; there will be very little pain in the wound after dressing, and it will heal in a few days, leaving no scar."

Dr. Fenger said the operation had been eminently satisfactory, and he was confident that a successful growth would result. The first dressing will be made in ten days, and by thirty days it is expected the successful evidences will assert themselves.

Mr. Dickerson is 44 years old. A year ago a cancerous growth appeared on his thigh, and last summer it was removed. The affliction, in medical phrases, is known as the carcinoma of the derma, or skin, and is sometimes called the flat carcinoma. It is one of the species that has not injured the tissues which prevent grafting. The wound left by the removal of the growth is located on the external and posterior aspect of the thigh and extends from the brim of the pelvis about six inches below the great trochanter of the femur. This extends also to the groin. The formation was superinduced by amyloid kidneys and albuminuria. In September Dr. Fenger attempted to graft upon the wound the skin of two she-goats which were prepared with care. The grafting was made the same as human flesh. The operation took about four hours. The grafting has lately been disappearing, and it is believed to have been absorbed.

HOW THE PATHOGENIC BACTERIA DO THEIR HARM.

BRIEGER AND FRANKEL have studied this question. Of course, the first condition for successful inquiry was to employ pure cultivations of the organism experimented upon. Basic bodies, denominated "toxine," had already been found in several pathogenic microorganisms, such as the bacillus of typhoid, tetanus, cholera, etc. Yet it was found that this toxine did not invariably call forth all the phenomena of the infectious diseases due to the bacilli, from pure cultivations of which it had been obtained; the supposition, therefore, seemed fair, that, besides the already found chemical bodies, there were other substances which played a momentous part (*The Edinburgh Medical Journal*). Brieger and Frankel considered that Loffler's bacillus of diphtheria was well adapted for their purpose, because it is now beyond doubt that this organism is the genuine cause of diphtheria. Loffler had already called attention to the fact that this bacillus, when inoculated on animals, guinea pigs and pigeons, colonized only the immediate neighborhood of the infected spot, yet grave alterations of texture and organs and speedy death of the animals experimented on followed. This connection of events could only be explained in this way—that the bacilli produced by their local multiplication a substance of exceedingly poisonous properties, which spread over the whole organism, and, independently of the bacteria, did its deadly work. Brieger and Frankel consider that they have proved that Loffler's diphtheria bacillus engenders in its pure cultivation a poisonous, soluble substance separable from the bacteria, and which, when injected into susceptible animals, calls forth the same phenomena as the injection of the living micro-organism. The authors also have settled that this substance is destroyed by a heat of 140° F.; that it can stand a heat of 122° F., even in presence of excess of muriatic acid. This last fact of itself speaks against the supposition that the poison of the diphtheria bacillus is a ferment or an enzym. Further examination of this substance showed it was not a ptomaine or toxine; no crystallizable substance, save kreatinin and cholin, was obtained. Shortly summing up their investigations, the authors seem to have discovered in the diphtheria bacillus a substance belonging to the albumen series of bodies, which has poisonous properties, and causes the phenomena of diphtheria when injected. They propose to give it the name of "toxalbumine." In the living body they consider that the bacteria build up and separate their toxalbumine from the albumen of the tissues. Brieger and Frankel also examined typhoid, tetanus, and cholera bacteria, and staphylococcus aureus and watery extracts of the internal organs of animals killed by anthrax, in the same way as they had examined the diphtheria bacillus, and found in all of them bodies which, according to their chemical behavior, were albuminoids, were poisonous, and could therefore be aptly called toxalbumines. The road from normal constituents of the body to substances of the most dangerous kind seems a very short one, and our organism itself may be looked upon as the proximate cause of morbid conditions let loose by the life activity of bacteria.

THE AMERICAN CHEMICAL SOCIETY.

SUBSEQUENT to the meeting of the American Chemical Society held in Newport, R. I., on August 6 and 7, 1890 (of which an account was given in the SCIENTIFIC AMERICAN of August 30) it was decided by that organization to call a second general meeting which all chemists, whether members of the society or not, should be invited to attend.

At the October and November meetings of the American Chemical Society, a committee of arrangements was appointed, consisting of five members, with Prof. A. A. Breneman as chairman. This committee went actively to work and in due time announced that a meeting would be held at the University of Pennsylvania in Philadelphia on December 30 and 31. This season of the year was chosen, as many of the leading chemists hold professorships in different universities, and could not conveniently be present at any other time during the winter months.

On the morning of the 30th the chemists were gathered in the lecture room of Professor George F. Barker, and the meeting was called to order by the president of the society, Prof. Henry B. Nason, of the Rensselaer Polytechnic Institute. An address of welcome had been promised by Dr. William Pepper, provost of the University of Pennsylvania, but owing to illness he was unable to be present and sent a letter in which he expressed his gratification in having the society meet at the university, and referred to the importance of its work. Prof. Barker in a brief speech extended the courtesies of the chemists of Philadelphia, and announcements were made of the entertainment that had been provided for the visitors.

The following papers were then read: "Note on Certain Reactions for Tyrotoxicon"—H. A. Weber. "The Relative Merits of the Wankiyn and the Adams Method in the Estimation of Fat in Milk Analyses"—J. F. Geisler. "Exhibition of Alchemical Medals"—H. C. Bolton. "Method of Determining Indigo for Commercial Purposes"—F. A. Owen. "On a New Gas Burner"—L. H. Friedburg. "A Porcelain Gooch Crucible"—G. C. Caldwell. "Some New Laboratory Fixtures"—G. C. Caldwell.

A luncheon in the university restaurant was provided for the chemists by the local committee, after which an excursion was made to the factory of the Welsbach Incandescent Gaslight Company at Gloucester, N. J. This proved of special interest, and in addition to the manufacture of these lamps, the company exhibited 150 kilogrammes of lanthanum and ammonium nitrate; 100 kilogrammes of neodynium and ammonium nitrate; 10 kilogrammes of praseodynium and ammonium nitrate; 10 kilogrammes of yttrium oxalate from the mineral fergusonite and a like quantity from the mineral gadolinite; also 50 kilogrammes of zicornium nitrate. Probably no such exhibition of salts of these rare metals was ever made in this country before.

The evening was devoted to a reception given by the chemists of Philadelphia to the American Chemical Society and their friends at the Manufacturers' Club on Walnut Street.

In the morning of December 31, an important meeting of committees of conference, to consider the question of a general organization among chemists in America, was held, and accredited representatives from the American Chemical Society, the chemical section of the American Association for the Advancement of Science, the Association of Official Agricultural Chemists, and the Washington Chemical Society met in consultation. The results of their deliberation were embodied in a series of resolutions, the purport of which was to postpone further action until the meeting of the American Association in Washington, next September.

The society then held its regular session, with the newly elected president, Prof. Geo. F. Barker, in the chair. The proceedings began with an inaugural address by the president, in which the border line between physics and chemistry was discussed with considerable ability. What had been accomplished was mentioned, and the lines along which future discoveries were likely to be made was indicated.

The following papers were then presented before the chemists present: "Chemical and Physical Changes attendant upon the Sterilization of Milk"—A. R. Leeds. "On the Necessity for the Systematic Inspection of Wells in Cities and Towns"—Durand Woodman. "Experiments in Milk Analysis"—Elwyn Waller. "The Chemical Products of Some Disease Germs and Their Physiological Effect"—E. A. Schweinitz. "National and State Chemists in Criminal Trials"—Clark Bell.

After these were read and discussed the meeting adjourned. Luncheon at the university restaurant followed, after which the members separated to visit the different works to which they had been invited. These included the United States Mint, the Franklin Institute, the Baldwin Locomotive Works, the Pennsylvania Museum and School of Industrial Art, the brewery of the Bergner & Engel Brewing Co., and the central station of the Edison Electric Light Co. The local committee, consisting of twenty members under the chairmanship of Professor Barker, deserve special credit for the entertainment which they provided for the visiting chemists.

Nearly one hundred chemists attended the meeting, among whom were Prof. A. B. Prescott, of the University of Michigan, Ann Arbor; Prof. C. E. Munroe, of the U. S. Torpedo Station, Newport, R. I.; Prof. J. H. Appleton, of Brown University, Providence, R. I.; Prof. W. L. Dudley, of the Vanderbilt University, Nashville, Tenn.; Prof. Edward Hart, of Lafayette College, Easton, Pa.; Prof. F. W. Clarke, of the U. S. Geological Survey, Washington, D. C.; Prof. R. O. Doremus, of the College of the City of New York; Prof. Elwyn Waller, of the School of Mines of Columbia College, New York City, and others. M. B.

OBTAINING OXYGEN FROM THE AIR.

A NEW process has been patented for obtaining oxygen from the air. At a red heat a mixture of lead monoxide and an alkaline earth will absorb oxygen, with the formation of lead dioxide and a plumbate of the alkaline earth employed; and if carbonic acid be then passed over the mass the absorbed oxygen will be driven off. The applicant proposes to apply this reaction to the recovery of oxygen from the atmosphere. He passes air over a heated mixture of lead monoxide and lime, thereby absorbing the oxygen and allowing the nitrogen to pass off—$2\,CaO + PbO + O = Ca_2PbO_4$. When the mixture has been saturated with oxygen the air is turned off. Carbonic acid is introduced, expelling the oxygen and itself combining with the remaining calcium oxide—$Ca_2PbO_4 + 2CO_2 = 2CaCO_3 + PbO + O$. The reaction is so rapid that at first only pure oxygen is evolved. Toward the close of the operation some carbonic acid is disengaged, but this can readily be removed by a suitable absorbing agent, such as lime or sodium carbonate. The mixture of calcium carbonate and lead monoxide now remaining in the retort is immediately treated (at a red heat) with air, or, to hasten the expulsion of the carbonic acid, with steam and air. The same reaction (the absorption of oxygen) is thus again brought about; and the process may be repeated at pleasure. It is also possible to recover the carbonic acid used in the process. Other metallic oxides—the lower oxides of manganese, for example—may be employed instead of lead monoxide. The oxygen of the pure dioxide (PbO_2 or MnO_2) and the corresponding metallic peroxides are also very easily driven off by carbonic acid.

USES OF SELENIUM.

UP to the present time very little use has been made of the remarkable property of selenium in changing its electrical conductivity upon exposure to light. At a recent meeting of the Physical Society, Mr. Shelford Bidwell read a very interesting paper on selenium, and exhibited a selenium cell controlling an electrical relay which could be adapted to a variety of purposes. In one arrangement, it was made to work an automatic watch light, turning on a little lamp on the approach of darkness, and extinguishing it again at dawn of day. By another arrangement the cell could be used to give notice if a railway signal light or a ship's side lantern should happen to go out.

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